MAY 1992

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BYTE

A McGRAW-HILL PUBLICATION

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3-D CAD
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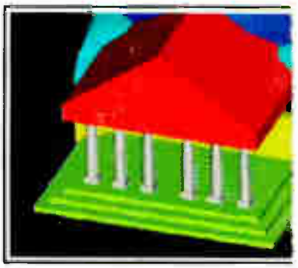

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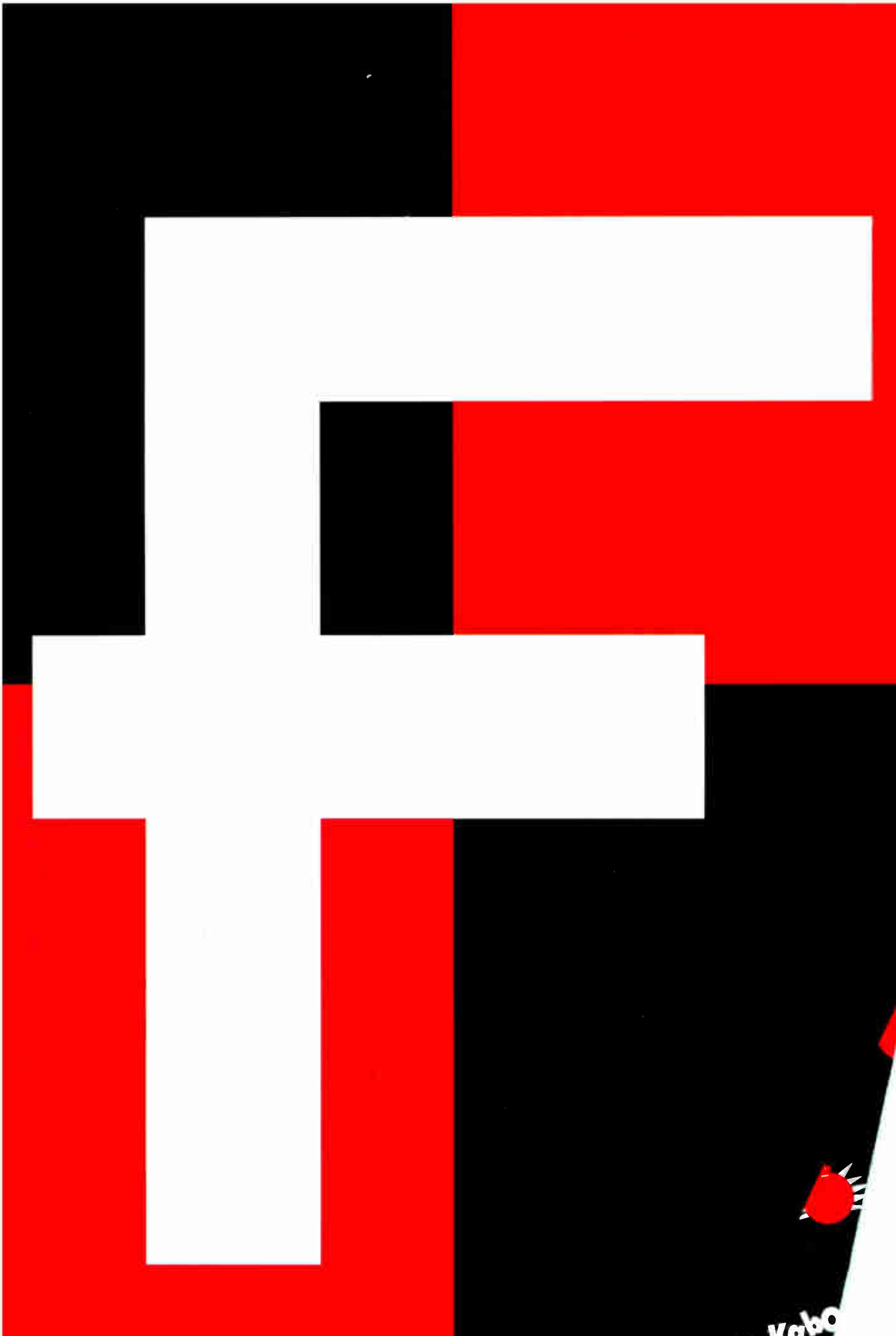
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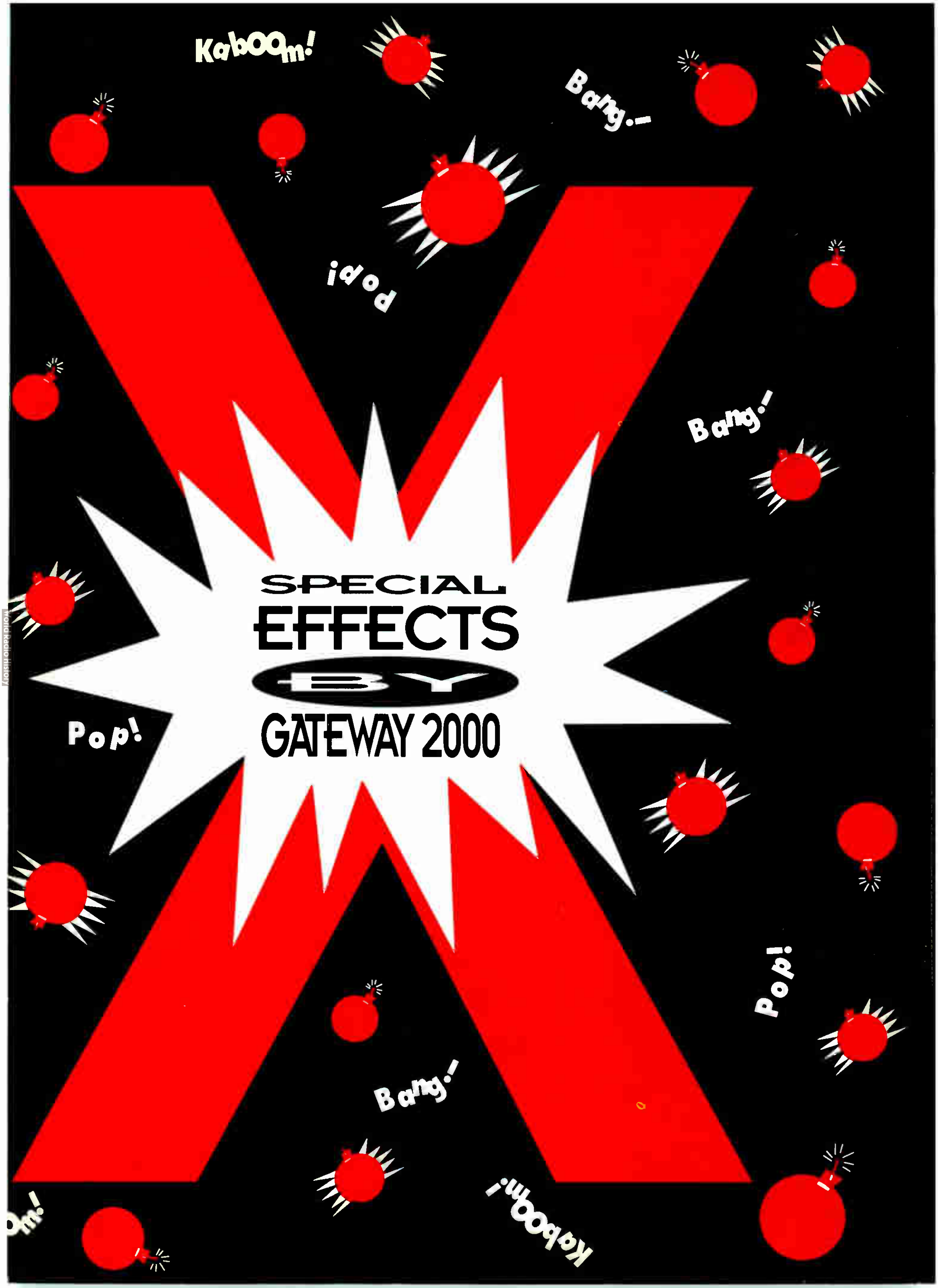
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Bang!
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Pop!
Bang!
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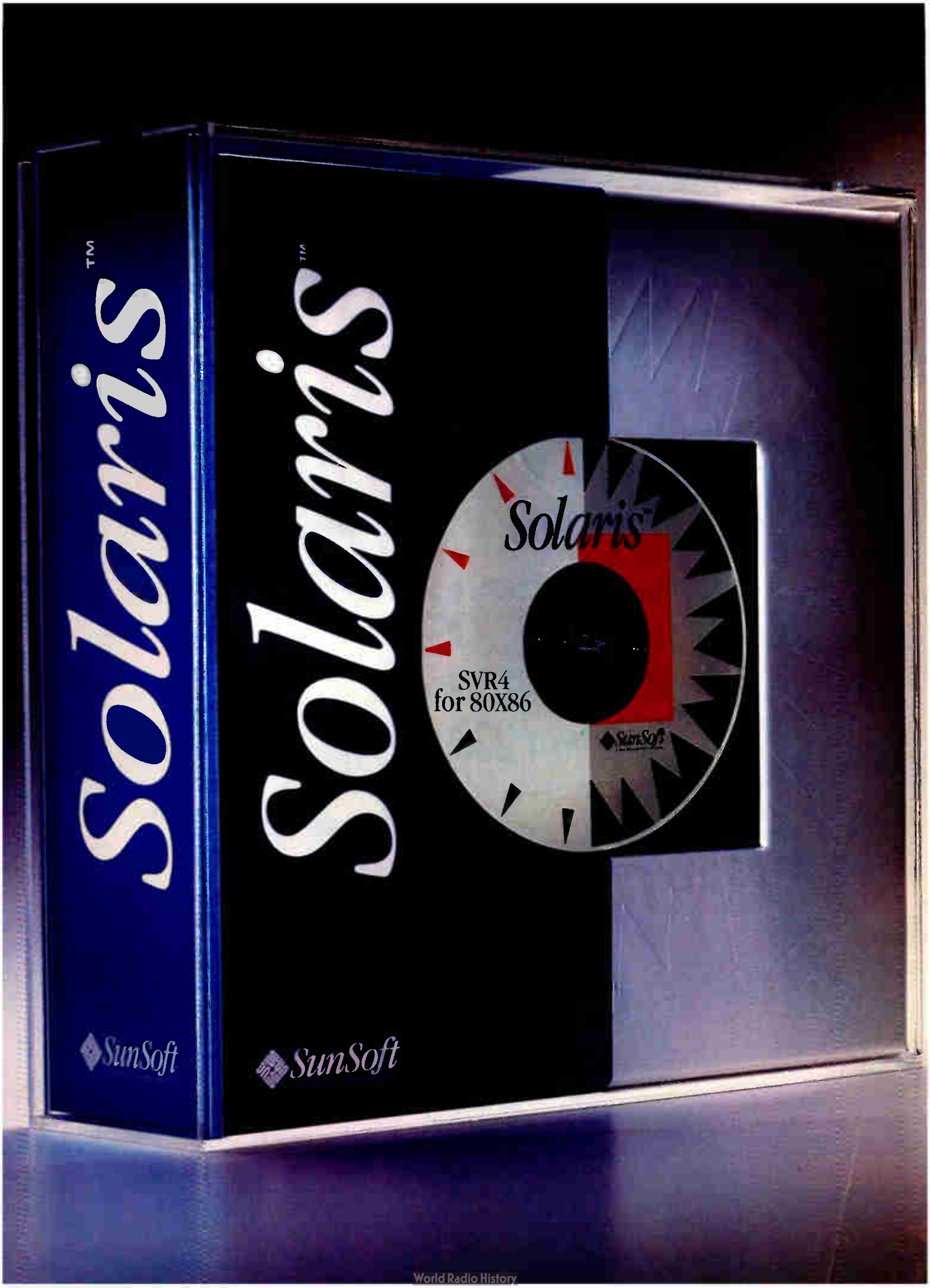
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May 1992 *Volume 17, Number 5*

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Intel's Double-Fast CPUs

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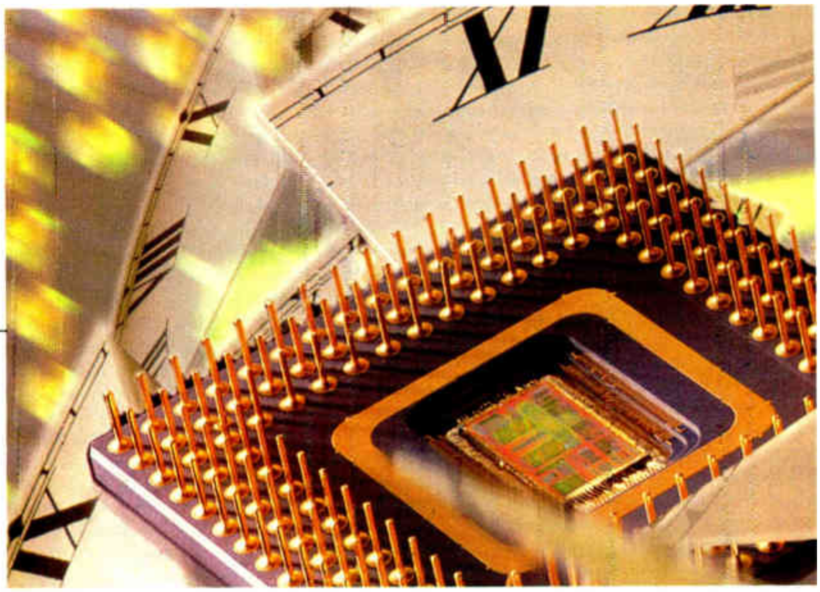

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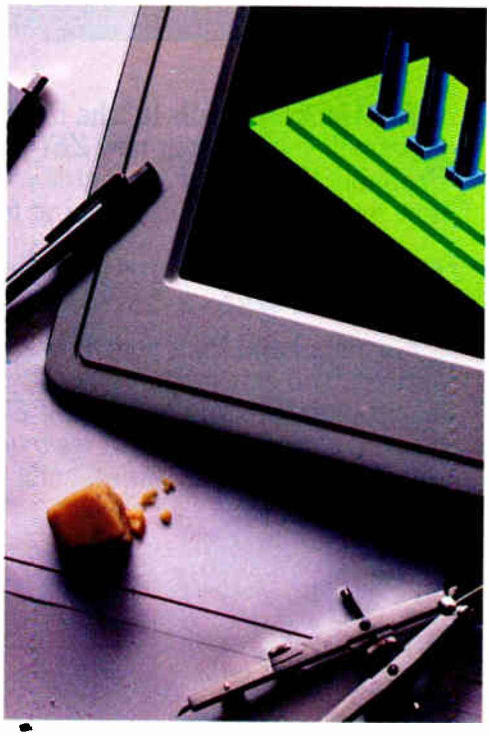

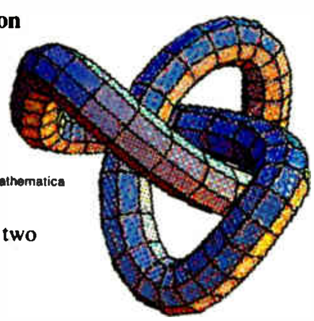

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OPINIONS

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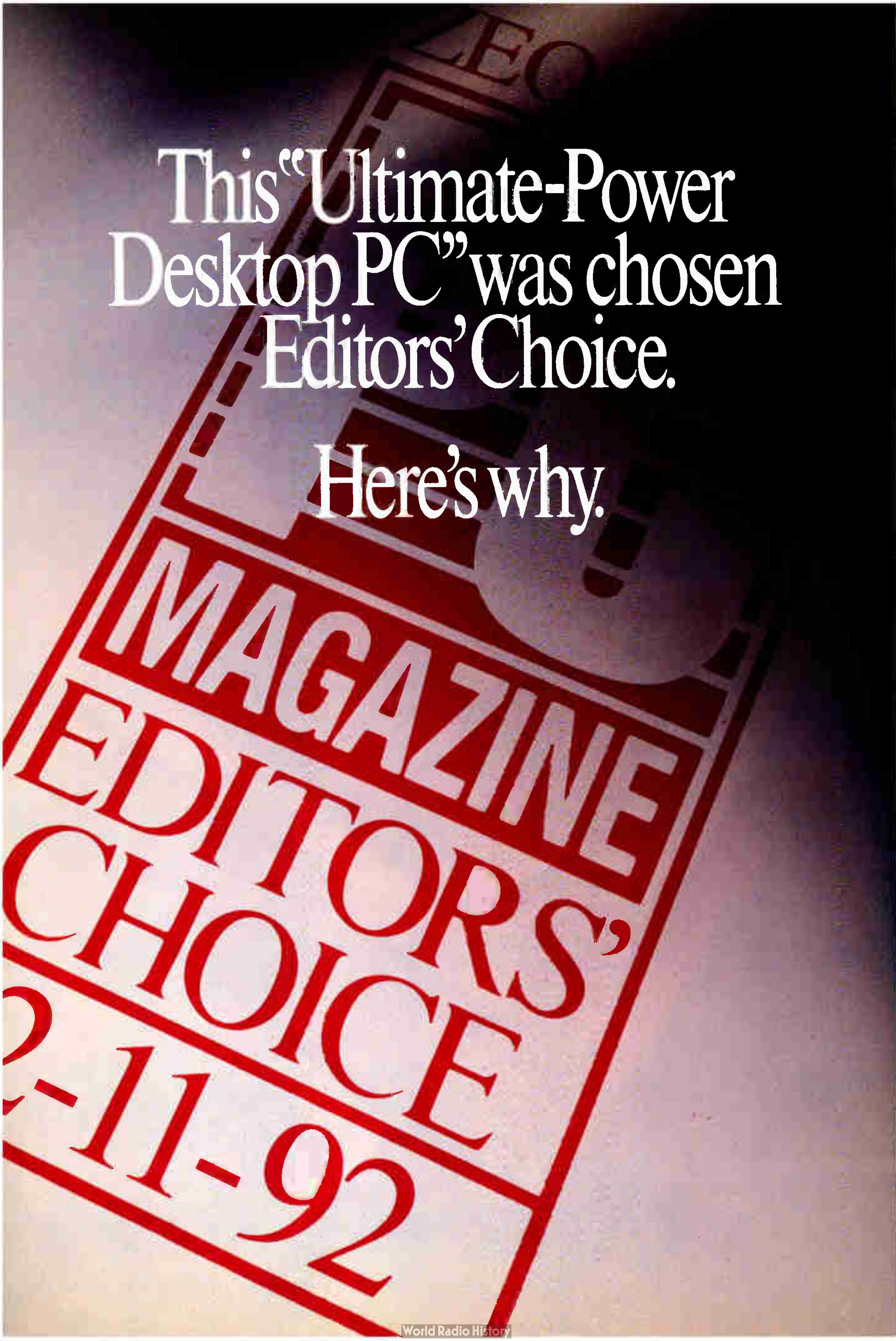
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are mounted on your ZEOS system board, one of the most advanced in the industry. And that's where your new system really begins to shine.

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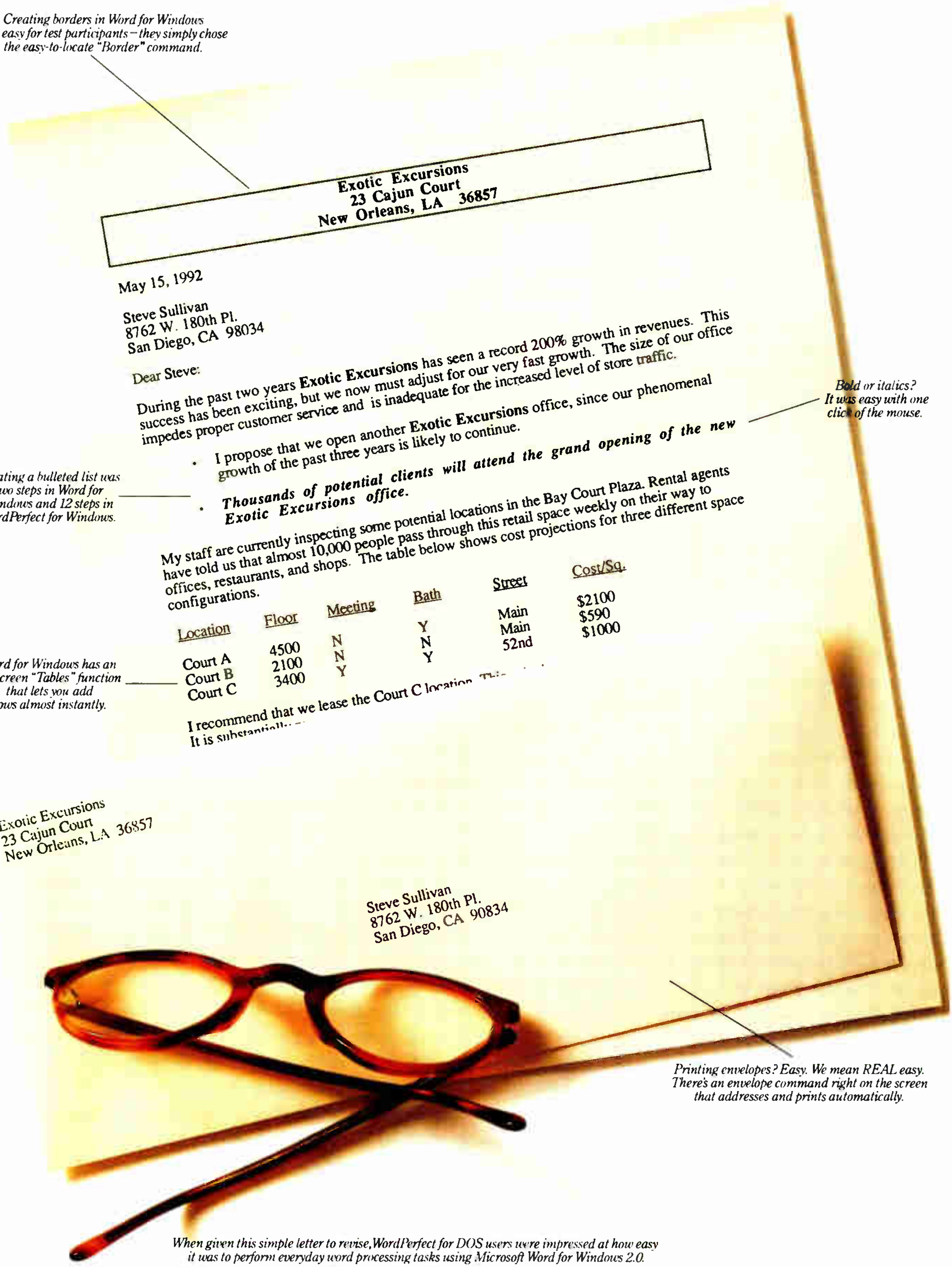
Creating borders in Word for Windows was easy for test participants – they simply chose the easy-to-locate "Border" command.

Bold or italics? It was easy with one click of the mouse.

Creating a bulleted list was two steps in Word for Windows and 12 steps in WordPerfect for Windows.

Word for Windows has an on-screen "Tables" function that lets you add rows almost instantly.



Exotic Excursions
23 Cajun Court
New Orleans, LA 36857

May 15, 1992

Steve Sullivan
8762 W. 180th Pl.
San Diego, CA 98034

Dear Steve:

During the past two years **Exotic Excursions** has seen a record 200% growth in revenues. This success has been exciting, but we now must adjust for our very fast growth. The size of our office impedes proper customer service and is inadequate for the increased level of store traffic.

- I propose that we open another **Exotic Excursions** office, since our phenomenal growth of the past three years is likely to continue.
- ***Thousands of potential clients will attend the grand opening of the new Exotic Excursions office.***

My staff are currently inspecting some potential locations in the Bay Court Plaza. Rental agents have told us that almost 10,000 people pass through this retail space weekly on their way to offices, restaurants, and shops. The table below shows cost projections for three different space configurations.

Location	Floor	Meeting	Bath	Street	Cost/Sq.
Court A	4500	N	Y	Main	$2100
Court B	2100	N	N	Main	$590
Court C	3400	Y	Y	52nd	$1000

I recommend that we lease the Court C location...

Exotic Excursions
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Steve Sullivan
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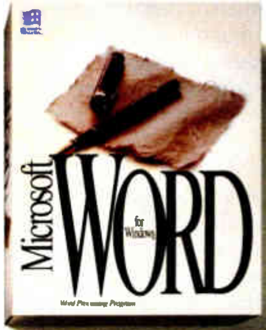
Printing envelopes? Easy. We mean REAL easy. There's an envelope command right on the screen that addresses and prints automatically.

When given this simple letter to revise, WordPerfect for DOS users were impressed at how easy it was to perform everyday word processing tasks using Microsoft Word for Windows 2.0.

No wonder WordPerfect users prefer Word for Windows. It has easy written all over it.



In a recent test conducted by the National Software Testing Labs (NSTL), nearly eight out of 10 WordPerfect* for DOS users preferred Microsoft* Word for Windows™ 2.0 over WordPerfect for Windows. The reasons were plenty.

They were amazed at how Word for Windows put them one step away from accomplishing everyday word processing tasks with, in many cases, one simple click of the mouse. Which may have surprised them. But it didn't surprise us. After all, we designed Word for Windows around them.

Every week during the development of Word for Windows, we invited WordPerfect users to bring in their letters, memos, or whatever business documents they use in their own jobs, and try them out using Word for Windows. Our Product Development people at Microsoft called these sessions "usability studies." Which is just a fancy, shorter way of saying "what-do-people-use-a-word-processor-for-and-how-can-we-make-it-easier-for-them-to-use-it."

These studies not only helped us to design features that make everyday tasks easier, but helped us to make the more advanced word processing features like grammar checking, drawing and charting, easier to use as well.

See for yourself why nearly eight out of 10 WordPerfect users preferred Word for Windows, and take advantage of our special $129 offer,* by calling (800) 323-3577, Dept. Y74. If, for any reason, you're not completely satisfied with Word for Windows 2.0, we'll gladly return your purchase in full.** If you'd like, we'll also send you the files you need to test Word yourself. Then you, too, can have the last word on ease.

Microsoft

Offer good for current licensees of WordPerfect, MultiMate, WordStar,* MS* Word for MS-DOS* and DisplayWrite.* Please allow 2-4 weeks for delivery upon receipt of order by Microsoft. Offer expires 6/30/92. Limit one per customer. Reseller prices may vary. Call for system requirements. **If you're not satisfied with Word for any reason, return the product to Microsoft within 90 days with proof of purchase for a full refund. Offer good only in the 50 United States. To receive only the NSTL test results: In the United States, call (800) 323-3577, Dept. Y74. For information only: In Canada, call (800) 563-9048; outside the U.S. and Canada, call (206) 936-8661.

EDITORIAL

DENNIS ALLEN

MAC CLONES

Is there room for a Macintosh-clone market? A company called NuTek in Cupertino, California, thinks so. At CeBIT, the world's largest trade show for computers in Hannover, Germany, NuTek quietly introduced what could be the basis of a Mac-clone industry.

What NuTek is selling is a set of three chips with an operating system that the company says lets hardware makers build Mac IIci–compatible systems. In a nutshell, NuTek says that its chip set emulates the ROM inside the Mac, and, when used with NuTek's operating system, a manufacturer can easily build systems that run Mac software.

The possibility of a Mac-clone market raises the question of whether there should be one

To get around actually cloning the Mac user interface, NuTek incorporated Motif as the user interface bundled with its operating system. Motif, which is better known in Unix circles, is similar enough to the Mac user interface that most folks won't mind the differences.

I saw a working system-board prototype, which was also designed by NuTek, that used the chip set. The board uses a Motorola 68030 CPU chip, and it supports Apple's NuBus to accommodate add-in cards designed for the Mac. NuTek plans to sell the board or just the chip set to hardware makers at prices that should result in competitively priced Mac IIci–compatible systems.

Based on the demonstration alone, it's impossible to say whether NuTek has accomplished all that it claimed. You can bet that BYTE will find out, though, and you can expect to find a story that delves into the technical matters in our next issue.

The bigger question for now is whether there ought to be a so-called Mac-clone market. That's a particularly tough question for Apple, which has done everything it could to block such efforts by dogmatically filing "look-and-feel" lawsuits.

The problem for Apple—as surely CEO John Sculley must realize—is that the installed base of computers running Mac software has been limited to only what Apple sells. I suppose it's nice to have the entire pie to yourself, but sometimes that means you will have to settle for a smaller pie.

Think about it this way: If you were a software developer, would you pour your efforts into developing a product for Mac or DOS systems? If you're looking for the largest market potential, you'd have to answer in favor of DOS. There are simply many more DOS systems than Macs. Period.

The bad news for Mac users is that most of the software development occurring right now is not for the Mac—it's for DOS and Windows. Sure, much of that software will eventually be ported to the Mac, but meanwhile the leading edge that Apple sold Mac users will evaporate. Without that leading-edge appeal, it's unlikely that the Mac will prosper, and the Mac will, in effect, become just another Windows machine.

That's not bad news just for Mac users, that's *really bad* news for everyone. As computer users and buyers, we need alternative solutions. Generally, that's what Apple has offered—a viable alternative to DOS systems and DOS applications. But as software development efforts are lured away from the Mac, Apple's alternative may not be so viable.

Things don't have to be that way. If Apple were to simply condone a Mac-clone market by licensing its technology and stop intimidating smaller companies with dubious look-and-feel lawsuits, the tide would turn. A number of Asian manufacturers would jump at the chance to build Mac-compatible systems. There's also a ready market waiting—those who would like to run Mac software but are deterred by the relatively high cost of Macs and buy PCs instead.

For Apple, there's money to be made in licensing its technology. There's even more money to be made in expanding the Mac market and attracting more software developers to write the kind of software that has separated the Mac from the PC. There's no money to be made, however, if a lack of new software for the Mac sends buyers to the PC makers.

Whether NuTek's chip set is the start of a Mac-clone market is uncertain for now. What is certain is that there is a definite need for Mac-compatible machines. A lot will depend on Apple. Apple staked its reputation in the 1980s on being an industry maverick. What Apple does now will determine its position for the rest of the decade, and we'll learn whether Apple wants to be a true industry leader or just part of the herd.

—Dennis Allen
Editor in Chief
(BIX name "dallen")

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LETTERS

Bugged by Windows

In "Why Wait for NT and Win32?" (December 1991), Walter Oney mentioned that "bugs surfaced in WINMEM32." I was wondering what those bugs might be. I called Microsoft, but it did not acknowledge any bugs in the current version of WINMEM32.

I was also wondering about the flat model. Oney certainly makes it sound like the way to go, but I haven't been able to figure out how you can have multiple instances of a flat application. Am I simply not thinking hard enough? Or did Oney not mention this as a negative of using a flat model?

Ken Brown
Battle Ground, WA

My information on bugs comes from statements made by two compiler vendors in public forums. I would expect the bugs to lie in the area of reallocation. The comments came from high-level people, and they may have been referring to problems that surfaced when they tried to use WINMEM32. Among these problems are that some application programming interfaces require that `GlobalHandle(SELECTOROF(ptr))` *be valid, and the selector returned by WINMEM32 won't have a handle; and regular Windows interrupt handling won't work for interrupts coming from a 32-bit code segment.*

You're right that you can't have multiple shared instances of a flat-model application, because the code has linear address pointers to the data. Sharing requires either a nonflat data selector (which has its own associated problems) or different page tables per instance. My feeling, however, is that any application that requires 32-bit power is so large that you wouldn't want two of them running at the same time.—Walter Oney

Ample Waves of Data

We appreciate that Minitab was included in Peter Wayner's review of statistical software ("Ample Waves of Data: Five Tools to Help You Stay Afloat," January) and would like to provide additional information that we believe will be of interest to BYTE readers.

Wayner states that "if the user interface is one of the selection criteria you care most about, you should buy a Mac or wait for a Windows version." However, release 8 of Minitab, which began shipping last November, has a user interface that was designed following Windows guidelines. And since it operates under DOS, the user doesn't need to change operating systems. We understand that your review was completed prior to this version becoming available.

Wayner says that "large parts of Minitab's manual cannot be understood by statistics novices" and states a preference for a competitor's manual that includes case histories. *The Minitab Handbook,* a basic statistics text of over 300 pages of statistical analyses and examples, ships with every copy of Minitab sold at retail. Also, a number of statistical textbooks use Minitab in their analyses, as do specific Minitab supplements to many leading statistical textbooks. Our records show that these materials were shipped to BYTE.

Wayner states that, at press time, Minitab had introduced a separate package for manufacturers who do quality-control analysis. In fact, quality-control capabilities have been included in Minitab since 1989, as is our *Quality Control and Improvement Supplement,* which we also shipped to BYTE.

Finally, we are concerned about the statement "Mac-based analysts should be wary of using either Minitab or Systat with difficult numbers." This could lead some readers to mistakenly infer that computations done by Minitab's Regress command are suspect. In fact, it is very reasonable for a statistical package to warn of instability and refuse to proceed in some situations.

One of Wayner's test cases used a response variable $Y = 1, 2, \ldots, 9$ and a predictor variable $X = 10001, 10002, \ldots, 10009$. This problem is unstable in the sense that relatively small changes in the input (in the sixth significant digit) can result in relatively large changes in the estimated intercept and slope (in the second significant digit). Thus Minitab will refuse to solve the problem unless you use the Tolerance subcommand.

Elizabeth Edmonston Clark
Public Relations
Minitab, Inc.
State College, PA

I did not know about the new version of Minitab, and I regret that I did not receive The Minitab Handbook *and the quality-control supplement. The DOS version with the Windows-style user interface sounds like a good addition.*

The section on numerical stability did not do justice to a topic that has generated thousands of Ph.D. dissertations over the decades, but it did touch on some of the deeper problems about the way in which statistical packages deal with numbers.

My comments about Minitab's numerical stability are based on its conservative approach to ill-conditioned problems. The software never made mistakes; it just balked at solving some problems. So did SPSS and Systat. When the problem was inverted, Minitab, Systat, and SPSS changed their minds and sailed through the problem without complaint. This is because most statistical packages look at only half of the numerical stability of a problem. Several of the other packages got the right answers in both formulations. Neither Minitab nor any other package presented wrong answers.

When I did the review, I didn't have access to any source code or any details of the implementation, so I was forced to view the software as a black box. (Users will have the same problem.) I decided that the best software was the software that presented the right answers as

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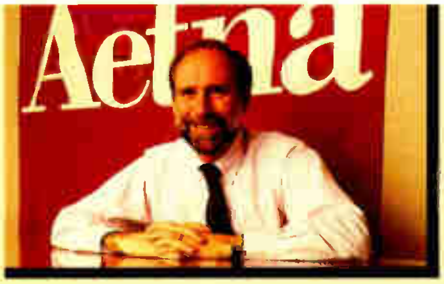

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K. E. Peacock
Data Administrator
City of Saskatoon, Saskatchewan

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often as possible and didn't balk at solving a problem unless it had to. Software designed this way is more usable, and that's why I liked SAS. It warned about potential problems and went on to present the correct answer. This is the best of both worlds. Minitab was more conservative.—Peter Wayner

Lee Out of Control

On reading Leonard Lee's "Computers Out of Control" (February), my first reaction is to fear his recommendations. They scare me! Progress in software engineering cannot exist without innovation, and innovation cannot exist without an open and creative atmosphere within which to experiment. Such an atmosphere cannot, however, exist with Lee's proposals.

What would the state of the art be if it had been regulated just 10 or 20 years ago? How many advances would have been lost? Would we just now be hailing software such as DOS 1.0 as the ultimate in programming?

Lee points out various examples of software failure but ignores the merits of the same programs. How many Scud missiles would have gotten through without the [Patriot Missile System] software? How often would phone service be disrupted if operators had to manually oversee those same 12 million calls?

The truth is that no human being is error-free—even software engineers make mistakes. What is needed is not alarmism. The sky is not falling. Better and more extensive verification should be mandated for all software that involves humans. But don't shackle the engineers unless you prefer to live in the dark.

Scott Huntwork
San Bernardino, CA

Overhyped on Multimedia

I am a novice to the computer world, but not to current digital technology—I've run a recording facility for 15 years. I am writing to you about the chaos surrounding the overhyped and underdeveloped multimedia standard. After spending a small fortune on hardware and software in the last year, I've come to the conclusion that the industry consists of a bunch of idiots.

The technology is there, so why do companies set such low standards for audiovisual applications and mislead buyers time and time again? I bought a sound board that specifically states 44.1-kHz sampling rates and stereo, only to find that it samples at 44.1 kHz in mono but at 22 kHz in stereo. To boot, it wasn't 16-bit, but 8-bit sampling, which sounds like a 1960 pocket radio.

Where are the Windows extensions? What about the people out there who have video-capture boards, sequencer software, MIDI cards, and high-end animation packages and need to combine them all for presentation purposes and video projects? It seems that multimedia is just another way to push expensive software and hardware on the public with no interactivity other than to watch somebody's creations.

What about people like me who create for a living? Do I need an expensive read-only CD-ROM drive when I own digital mega decks and produce CDs for the music market? The answer is no. Many of my associates feel the same way, that multimedia is just another ploy for a quick buck and that companies have no intention of creating a true interactive platform.

Multimedia also means to create, and interactive doesn't mean just clicking a mouse button.

Richard Spychaj
Metuchen, NJ

Windows 3.1 Chaos

I want to thank Jerry Pournelle for his January column. I run Windows 3.0 with QEMM and Norton Desktop. I will think long and hard before attempting to install the Windows 3.1 upgrade. I will back up everything and cross all my fingers and toes!

David A. DeVere
Pittsburgh, PA

I'm still using Windows under Desqview; DOS applications lock up Windows at random intervals on my system. No one seems to know why.—Jerry Pournelle

Jerry Pournelle's Windows 3.0 "configuration tribulations" could have been partly solved by restoring Windows from the WORM drive, rather than installing it from scratch. Here's another suggestion: Simply use a compression utility like PKZip to compress Windows directories into files on another logical drive. My Windows directory is in D. I create E: \W and E: \W\S and then use PKZip to compress all the files in D: \Windows into E: \W\W.ZIP. The files in the D: \Windows\System directory go in E: \W\S\S.ZIP. Having all the files compressed into a single file makes them invisible to the Windows installation program and makes recovering them easy.

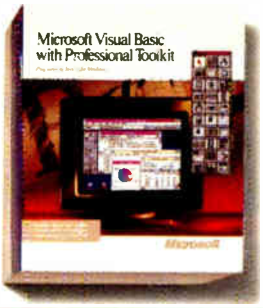
I also have a batch file that I run before shutting down my computer that updates important files that have recently changed (e.g., PKZIP -u E: \E\W_IMPORT D:\WINDOWS*.PIF D:\WINDOWS*.INI, and so on). Rather than updating the large E: \W\W.ZIP file, I prefer to use the smaller E: \W\W_IMPORT.ZIP file. This is not a substitute for a separate media backup, but at least this method makes recovering Windows and other changed files easier.

Dave Vales
Moscow, ID

Alas, that WORM drive is connected to a different machine. But, of course, you're right.—Jerry Pournelle

FIXES

- In "File Servers Face Off" (February), Tangent's Multi-Server included four 330-MB SCSI hard drives; the features table listed four 165-MB SCSI drives.
- The price for Intel's Net Satisfaxtion products included in "The 1991 BYTE Awards" (January) is incorrect. The Net Satisfaxtion server software sells for $799. The Net Satisfaxtion fax board for the PC is $499. We regret the error. ■



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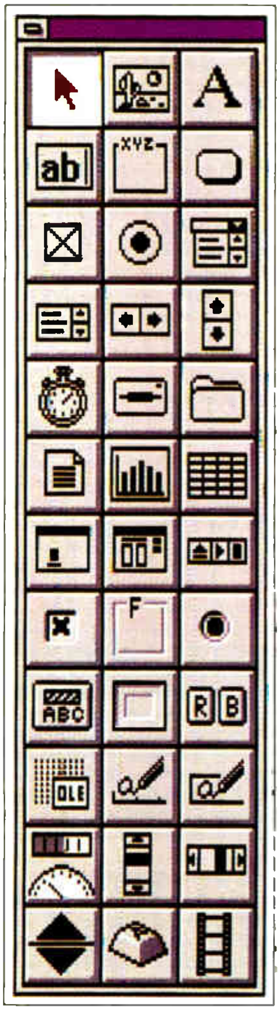

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NEWS

MICROBYTES

Microprocessors Start to Eclipse the Mainframe

Recent breakthroughs and announcements on several fronts make it clear that the future of computing—at all levels—lies in microprocessors. The reason has more to do with physics than markets. Computers are now so fast that their performance bottleneck is the speed at which signals pass on and off chips. It is simply not possible to build faster machines unless the delays inherent in interconnections between components are reduced. The solution is to cram everything onto one chip.

This fact was highlighted at this year's International Solid-State Circuits Conference session on emerging microprocessors, where details were disclosed about five dazzling new designs. The revelations gave rhyme and reason to Cray Research's recent announcement that it had licensed two RISC-chip designs: the SPARC processor pioneered by Sun Microsystems and a newcomer, the Alpha chip from DEC. Cray plans to use the Alpha RISC processor in its first-generation, massively parallel processing system, to be delivered in 1993. Also, NEC has developed a multiprocessing version of the R4000 RISC processor designed by Mips. The 50-MHz part includes cache-coherence circuitry. A four-processor system, scheduled to ship in May, is estimated to have a performance of 235 SPECmarks, claims NEC.

Grabbing the limelight at ISSCC was DEC, which discussed a new 100-MHz, 50-SPECmark version of the VAX processor—a complex instruction-set computer (CISC) chip—and the new Alpha RISC chip, slated to operate at speeds of up to 200 MHz. Texas Instruments and Sun talked about their new superscalar implementation of SPARC, code-named Viking. Fujitsu revealed a 290-MFLOPS single-chip supercomputer, and Hitachi disclosed a microprocessor with a reported performance of 1000 MIPS. Neither of the Japanese offerings is a commercial product yet, but both of DEC's chips and the Viking are targeted to ship this year.

With performance levels this high, it's no wonder that some analysts question the longevity of the Intel 80x86 and Motorola 680x0 architectures. As DEC's boosting of VAX makes clear, there's life left in CISC chips. Intel has hinted that its anticipated P5 chip could offer a performance of 100 MIPS. But even Intel's P5 superscalar chip includes a large amount of RISC in its design. And the P6, expected to be announced late in 1993, reportedly continues the trend with even more of the space on the chip devoted to RISC implementations. Whether it's CISC, RISC, or some combination of both, don't discount developments from any quarter.

—Trevor Marshall and Rick Cook

Using a number of robots, DEC employees manufacture the first of the company's new microprocessor chips at a facility in Hudson, Massachusetts. The company also plans to make these chips in South Queensferry, Scotland, starting this month.

NANOBYTES

At the International Solid-State Circuits Conference, the long-awaited SPARC Viking presentation generated less interest than DEC's announcements did. This was unfortunate because **Viking will let SPARC reposition itself as a performance-oriented architecture.** The chip, codeveloped by Sun Microsystems and Texas Instruments, has a fast integrated FPU and achieves a considerable degree of superscalar ability. Under best-case conditions, the CPU can execute 3 instructions per cycle, the companies said. At the maximum clock rate of 40 MHz, this suggests peak performance of 120 MIPS. □

IBM is creating a new supercomputing laboratory dedicated to developing a family of **highly parallel supercomputers** based on IBM technology. The company says that the Highly Parallel Supercomputing Systems Laboratory (Kingston, NY) will design, develop, and deliver a series of parallel supercomputing systems that use multiple RISC processors running AIX. Scientists and engineers will be able to use the systems to solve complex problems in financial modeling, long-range weather forecasting, geophysical modeling, and other applications. Information regarding the delivery of the first low-end HPSSL products is expected to be announced later this year. □

Motorola isn't abandoning its 68000 line of processors in the face of the RISC challenge, but the next major member of the family after the 68040 won't be the 68050; it will be the **68060**. Motorola is keeping mum on features, except to say that the chip will represent a major performance improvement over the 68040. One logical deduction is that it will feature a much wider internal bus, perhaps 128 bits. □

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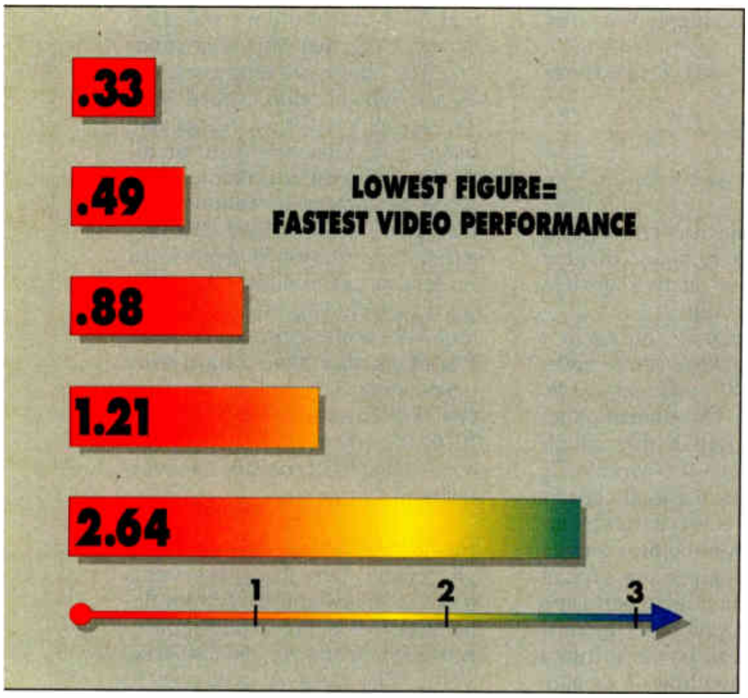

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NEWS

MICROBYTES

Alpha Not Just a Chip: It's the Future of DEC

Alpha is more than a chip for DEC: It is the name of the company's strategy for the next 25 years—a strategy that may be closely tied to Microsoft's 32-bit Windows NT (New Technology) operating system. Alpha encompasses a 64-bit RISC architecture, a single-chip processor, and a family of systems, technologies, and services. DEC is targeting Alpha at all sectors of the marketplace, from single-chip microcontrollers to mainframes. DEC's migration strategy is that Alpha is not optimized for any specific operating system; ports of VMS and OSF/1 to the Alpha chip are now under way. The company says that it will license development and production rights to the architecture to other companies.

The first version of the chip, to ship in July for $1559 each in quantities of 1000, offers 150-MHz performance, a physical address space of 16 gigabytes, and an external-cache interface that supports caches of up to 8 MB. At press time, DEC and Microsoft admitted that they are engaged in serious discussions to supply Windows NT to Alpha.

—D. L. Andrews

DEC's Dilemma: Progress Without Burning Bridges

At the International Solid-State Circuits Conference, DEC discussed two new chips that are not targeted at the workstation marketplace—at least, not for now. In fact, the chips' exceptional performance raises a difficult problem for DEC: how to introduce new technologies without destroying the company's core minicomputer business. Systems built around these new chips could undermine DEC's current models, so, for now, DEC will use the chips only in high-end machines.

The 50-SPECmark VAX chip is faster than today's multiprocessor VAX 6000/610 minicomputer, which is rated at 40.5 SPECmarks. The 0.75-micron, 3.3-V CMOS technology used in the chip allows 1.3 million transistors to be integrated into a space measuring 1.62 by 1.46 cm square. Housed in a 339-pin PGA package, the chip dissipates 18 W; permanently attached to the top of the package is a large copper heat sink. A 400-MHz oscillator, divided down to provide a four-phase 100-MHz clock speed, feeds the chip.

The Alpha processor is housed in a huge 431-pin PGA package (three times the size of an Intel 486) and uses 30 W of power at 200 MHz. One amazing fact about these new designs is how much power they dissipate. The 100-MHz VAX chip will reportedly have a total capacitance of 3200 pF. To achieve 300-ps internal-clock distribution requires a huge current of 43 A. By comparison, typical microprocessors deal in milliamperes and microamperes. The Alpha clock circuitry delivers enough peak power to run a 100-W lamp 200 million times a second. So don't expect Alpha and VAX notebooks for a while.

—Trevor Marshall

Microsoft Licenses Fractal Technology

Microsoft's Multimedia Publishing Group has licensed image-compression technology from Iterated Systems (Norcross, GA), says Dr. Alan Sloan, copresident of Iterated. The technology, based on fractal geometry, can reportedly compress images so that a CD-ROM can hold up to 75 times more than its normal capacity of about 650 MB of data.

Iterated supplies an image-compression board containing eight application-specific ICs used for compression; on the user side, decompression can be performed in software with some performance penalty.

Using Iterated's compression, a compression ratio of about 75 to 1 is suitable for archiving images, where images are recognizable. At 50 to 1, which is still significant compression, you get a distortion-free image, according to Iterated's vice president of marketing and sales Jan Ozer. "At 30-to-1 compression, your image is pretty much indistinguishable from the original," he said. Ozer says that for multimedia, where the quality is important, compression ratios ranging from 30-to-1 to 50-to-1 are the most desirable.

Iterated has been working on fractal image compression since 1987. In fact, Sloan and copresident Michael Barnsley wrote about the technique in the January 1988 BYTE.

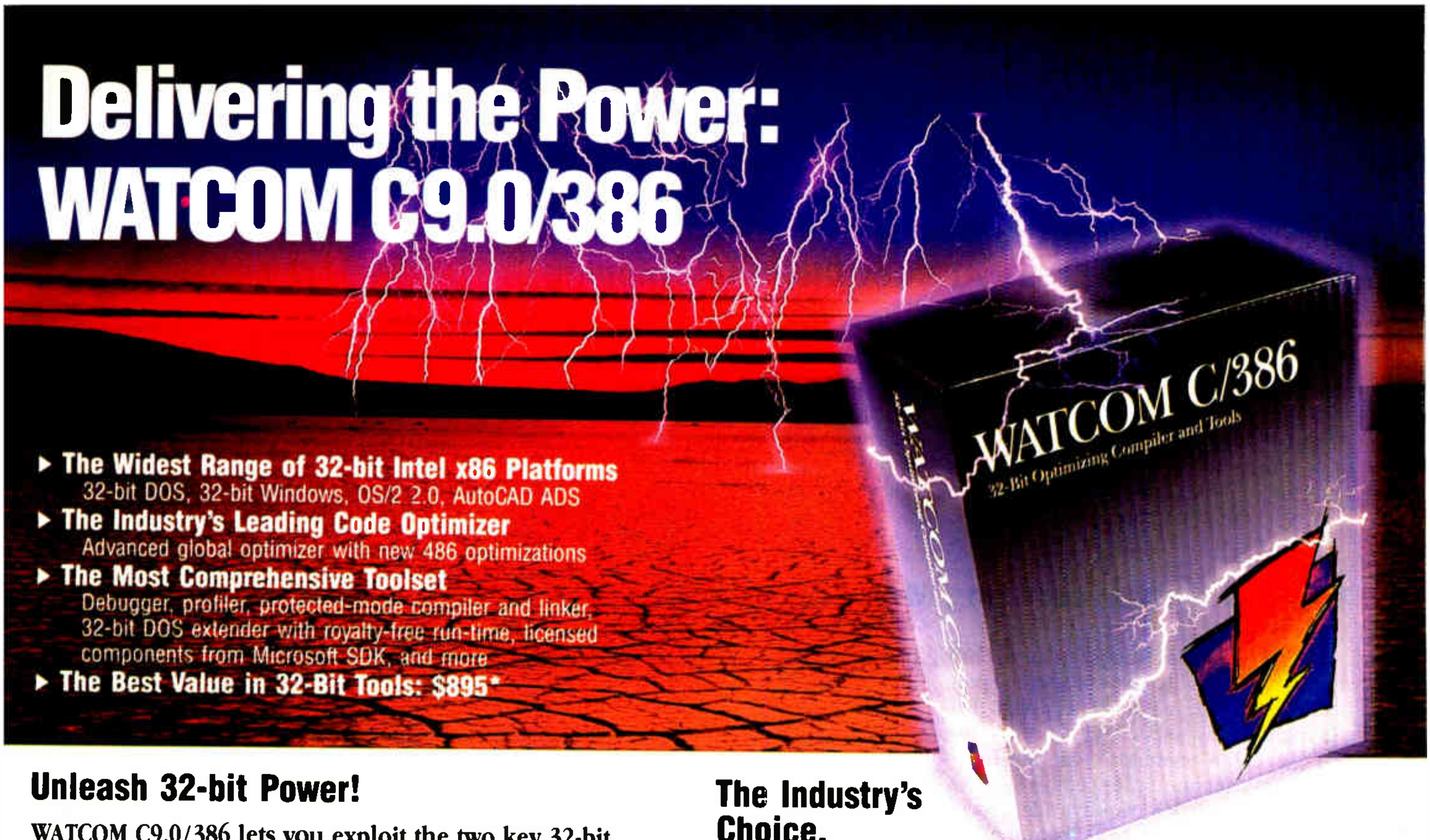
—Andy Reinhardt and D. L. Andrews

NANOBYTES

In a deal that no doubt made Advanced Computing Environment members sit up and take notice, Silicon Graphics, Inc., and Mips Computer Systems are expected to finalize next month a definitive merger agreement that will result in a company with annual sales approaching $1 billion, with ownership of roughly 76.5 percent by former SGI shareholders and 23.5 percent by former Mips shareholders. The charter of a new wholly owned SGI subsidiary called Mips Technologies will be to oversee and license the Mips processor architecture. SGI vows to continue selling Mips chips as a **"vendor-neutral"** RISC platform for ACE/ARC and other systems. SGI president Ed McCracken said that other ACE partners, including **DEC, Compaq, and Microsoft**, approved the deal. But Mips may have a hard time maintaining an "open" image when one of its largest customers owns it. With Microsoft and DEC in bed over Alpha, ACE could be dead as a doornail. □

Hewlett-Packard says that it will begin shipping later this year systems that use a new single-chip implementation of its Precision Architecture-RISC processor, the PA-RISC 7100. The chip is expected to achieve a rating of more than **120 SPECmarks.** The PA-RISC 7100, which HP says is compatible with previous PA-RISC-based systems, will operate at frequencies of up to 100 MHz. □

Apple and IBM have appointed **Joseph M. Guglielmi** as chairman and CEO and **Edward W. Birss** as chief operating officer of Taligent, the joint venture that will develop system software for RISC-class machines. Guglielmi left his position as IBM vice president and general manager, marketing and business development, Personal Systems. Birss was Apple's senior vice president and general manager of the Object-based Systems Division that produced the Pink operating system. □



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Novell's *Network C for NLM's SDK* includes C/386

The Industry's Choice.

Autodesk, *Robert Wenig, Manager, AutoCAD for Windows:* "At Autodesk, we're using WATCOM C/386 in the development of strategic new products since it gives us a competitive edge through early access to new technologies. We also highly recommend WATCOM C/386 to third party AutoCAD add-on (ADS and ADI) developers."

Fox Software, *David Fulton, President:* "FoxPro 2.0 itself is written in WATCOM C, and takes advantage of its many superior features. Optimizing for either speed or compactness is not uncommon, but to accomplish both was quite remarkable."

GO, *Robert Carr, Vice President of Software:* "After looking at the 32-bit Intel 80x86 tools available in the industry, WATCOM C was the best choice. Key factors in our decision were performance, functionality, reliability and technical support."

IBM, *John Soyring, Director of OS/2 Software Developer Programs:* "IBM and WATCOM are working together closely to integrate these compilers with the OS/2 2.0 Programmer's Workbench."

Lotus, *David Reed, Chief Scientist and Vice President, Pen-Based Applications:* "In new product development we're working with WATCOM C because of superior code optimization, responsive support, and timely delivery of technologies important to us like p-code and support for GO Corp's. PenPoint."

Novell, *Nancy Woodward, V.P. and G.M., Development Products:* "We searched the industry for the best 386 C compiler technology to incorporate with our developer toolkits. Our choice was WATCOM."

Microsoft Windows
PC Magazine Editors' Choice September 13, 1988 Watcom C Version 6.5
InfoWorld Best in its Class WATCOM C7.0 1989
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NEWS

MICROBYTES

Datapoint's 20-Mbps ARCnet Close to Shipping

By the time you read this, the long-awaited 20-Mbps version of ARCnet should be available from Datapoint (San Antonio, TX). The new system, called ARCnetPlus, is unique because it communicates with both the new 20-Mbps standard for ARCnet and the old 2.5-Mbps version at the same time and on the same LAN. This feature will lure ARCnet customers to accept it, although the nearly $1000 asking price for network-interface cards will do much to offset the attraction. The new ARCnet cards are twice as expensive as comparable 16-Mbps token-ring cards and only about 20 percent faster.

—Wayne Rash Jr.

Zinc-Air Batteries: Long May You Run

AER Energy Resources (Atlanta, GA) says that it will begin commercial production later this year on battery units that use a zinc-alloy anode and air as the reacting agent to generate power. The leading battery technologies today, such as nickel-cadmium or nickel-hydride, use an oxidizing agent (e.g., lead, cadmium, or lithium) within the battery chamber to power the reaction. AER is commercializing patented technology that Dreisbach Electromotive (Santa Barbara, CA) has already developed. Evaluation units should be available to computer manufacturers next month.

The zinc-air battery operates by allowing air to flow over the zinc anode to produce a chemical reaction, converting zinc to zinc oxide. To shut down the reaction, "air doors" at each end of the air plenum are shut off to stop the air flow, thus cutting off the oxygen supply to the zinc anode. To recharge the zinc-air battery, an external voltage is applied to reverse the reaction, converting zinc oxide back to zinc.

According to AER, the zinc-air battery offers up to four times the energy density of current leading battery technologies. With the higher energy density, the zinc-air battery can produce significantly longer operating times than competing batteries, the company says.

AER's vice president of marketing Frank Harris says that the zinc-air system will initially cost two to four times as much as nickel-cadmium batteries, but the company expects the price to drop quickly when volume production begins. AER is also planning to introduce a stand-alone 12-V zinc-air system for cars.

The zinc-air system looks promising, but the dimensions and weight of the prototype could be a problem for portable designs. The demonstration battery packs weigh 1½ pounds and include an air manager that adds an additional pound. The system has a footprint of 11¾ by 9⅘ by ⅝ inches. Harris says that the company will be able to manufacture the battery in a variety of configurations. Nevertheless, the additional weight of the air chamber could be an issue.

One of the traditional complaints about zinc-air batteries is that they are limited in how much energy they can provide at one time. But an AER spokesman said that the company's batteries can provide enough power to continuously run a 386-based portable for about 9 hours.

—Nicholas Baran

GeoWorks Announces Pen Versions of Desktop Environment

GeoWorks (Berkeley, CA) plans to introduce later this year a pen-based version of its popular GEOS (Graphical Environment Object System) operating environment. Called Pen/GEOS, the graphical interface is targeted at Intel-based palmtop systems costing less than $500, in particular 8088- and 8086-based systems.

Chips & Technologies joined GeoWorks at the Pen/GEOS announcement, promoting its single-chip F8680 personal computer (see the November 1991 BYTE) as the perfect companion to Pen/GEOS. A new startup company called Palm Computing (Menlo Park, CA), headed by former Grid vice president of research Jeff Hawkins, plans to introduce handwriting-recognition software and other applications for Pen/GEOS. Gordon Campbell, president and CEO of C&T, said that Pen/GEOS and the low-power PC/chip will result in sub-$500 pen devices.

—Nicholas Baran

NANOBYTES

While Intel's engineers are hard at work in getting the company's next generation of processors out the door, the company's lawyers appear to be working just as diligently. An arbitration decision handed down late in February awarded **AMD royalty-free rights** to manufacture and sell its Am386 line of processors without fear of legal action by Intel. The award was part of the remedies portion of an October 1990 decision that said Intel had acted in bad faith when it decided to secretly discontinue a technology exchange agreement with AMD, while pretending that the relationship still existed. □

A week after the arbitrator's decision, Intel filed in the federal court two complaints against Chips & Technologies. The company alleged patent violations regarding C&T's Super386 and SuperMath products and sought a temporary restraining order (which was denied) preventing C&T from transferring its processor designs to chip manufacturers, including Texas Instruments. According to C&T president and CEO

Gordon Campbell, the patents Intel is asserting against C&T are covered by a cross-license agreement that TI has with Intel. Over the past few months, Intel and C&T had discussed C&T products, and both companies had agreed not to take action until these issues had been resolved, said Campbell. Intel filed its complaints as C&T prepared to transfer the design to TI. Because of the standstill agreement, Campbell said, Intel's filing "was like the attack on Pearl Harbor." Campbell also said, "We told Intel that TI was willing to stand behind us legally...Intel chose to disregard all that." An Intel spokesperson said that the reason Intel took so long to file its suit (the C&T chips were announced last September) was because the company "needed to get ahold of the products and evaluate them." □

Introducing the NewWave Desktop Manager for Windows, version 4.0 from Hewlett-Packard.

NewWave converts all of your DOS and Windows files and programs into icons. Now you can get the most out of your PC, and your LAN, without using complex DOS, network or Windows commands. Work on the desktop with familiar office tools like the File Drawer, Wastebasket and Printer. Easily drag and drop icons to move, file, copy, print and throw away.

Get Organized.

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NEWS

MICROBYTES

New VIM Standard Holds Promise for Workgroup Computing

An unusual group of partners—Apple, Borland, Lotus, and Novell—have agreed to form a messaging standard that could make it easier for developers to write multiplatform, workgroup-computing applications. The standard will provide a protocol for passing messages between systems and over networks. It takes the form of an application programming interface for developers to use when trying to interface E-mail and other message services into applications.

Applications now require separate interface code for each of the many messaging standards available. This is a tremendous amount of work. The new specification, called Vendor-Independent Messaging (VIM), has its roots in a similar, but less feature-rich, specification called Open Messaging Interface (OMI) that Lotus announced last September.

Since the OMI announcement, the four companies participating in the VIM announcement have been working on expanding the specification to suit the needs of a wide range of applications and system-software vendors. Gursharan Sidhu, technical director of collaborative systems development at Apple and chairman of the VIM Steering Group, said that the VIM specification has nothing to do with the message-transport mechanism and is only intended to provide a way for applications to add messaging capabilities without having to deal with different interfaces.

—Owen Linderholm

Apple to Modulate Its System Software

Apple recently unveiled a broad array of new system-software technologies that the company expects will serve as foundational enhancements to the current core Mac OS. Expected to become available over the next two years, these new technologies will refine and extend System 7.0's software technology to apply it to new uses, including pen input and speech recognition.

According to Apple, the new functionality will let the company capitalize on customer demand for smaller, lighter products that are highly mobile. Among the announcements were details that the Open Collaboration Environment, a suite of programming interfaces and services that extend and complement the Interapplication Communication architecture, will include messaging, mail, directory, authentication, privacy, and digital-signature services. The interfaces are designed to permit easy third-party incorporation of existing and emerging messaging and directory technologies.

Apple said that future versions of its system software may evolve to support interfaces for pen input, a technology the company calls Rosetta, or the speech-recognition software recently shown in the U.S. and Japan under the name of Casper. Casper converts any speaker's verbal commands into actions on the Mac. It recognizes speech, parses it, and then turns it into a string of Apple event commands. Unfortunately, this technology is not yet ready for prime time: The successful recognition level during a demonstration was at best around 40 percent, and for complex commands, it was about 10 percent.

On a positive note, Apple's work in restructuring the architecture of System 7.0 is closer to seeing the light of day as a released product than is Casper or Rosetta. Extensions to System 7.0 will appear as software modules that users or developers can choose to add to System 7.0, if they wish. At periodic intervals, Apple will reintegrate some of these modules into the overall system and issue a new reference release of the full operating system.

For developers, the modular aspect is good. It will eliminate the onslaught of 7.x.x.x.x revisions each time a new machine is introduced, allowing the base operating system to remain stable. For users, the modular approach should keep memory requirements down. If you're not using a new imaging architecture, you don't put it in, and it doesn't consume memory. But the modular model could add significant drama to the life of someone in technical support. Company representatives on the receiving end of help-line telephone calls will need to know what each individual user has installed on a machine. A Control Panel that provides this information to the user would be a big help here. The company needs to implement a way to handle inevitable user woes that will result from weird modular mixes. ■

—Owen Linderholm, Larry Loeb, and Tom Thompson

NANOBYTES

Terry Rogers, vice president and general manager of Lotus's Communications Products Division, described the separate code issue where developers are required to create interface code for multiple messaging standards as "one of the main inhibitors to the growth of workgroup computing." A version of Lotus Notes supporting the **Vendor-Independent Messaging** application programming interface should be available before the end of September, Rogers said, while Lotus Notes 3.0, with support for workflow automation, should ship within 15 months. Rogers also said a version of cc:Mail supporting VIM should be released in June. □

At the System Software Forum, Apple demonstrated an **open scripting environment** that will give customers a choice of scripting tools. These tools will work across different off-the-shelf software products. □

The same week that Apple showed its open scripting environment in Napa Valley, **UserLand Software** (Palo Alto, CA) and Aldus jointly released a free UserLand Frontier 1.0 installation file that lets scriptwriters drive Aldus PageMaker 4.2 and sample Frontier scripts and PageMaker templates that illustrate how you can automate PageMaker using Frontier. □

Apple plans on releasing System 7.0 extensions over the next two years that will help bridge the gap between QuickDraw and PostScript graphical output. Many Toolbox routines will have to program PostScript output themselves, but with **El Kabong**, the code name for the project, the application code will be reduced considerably. Screen/printed output will be faster and more consistent. ■

The Fail-Safe PC

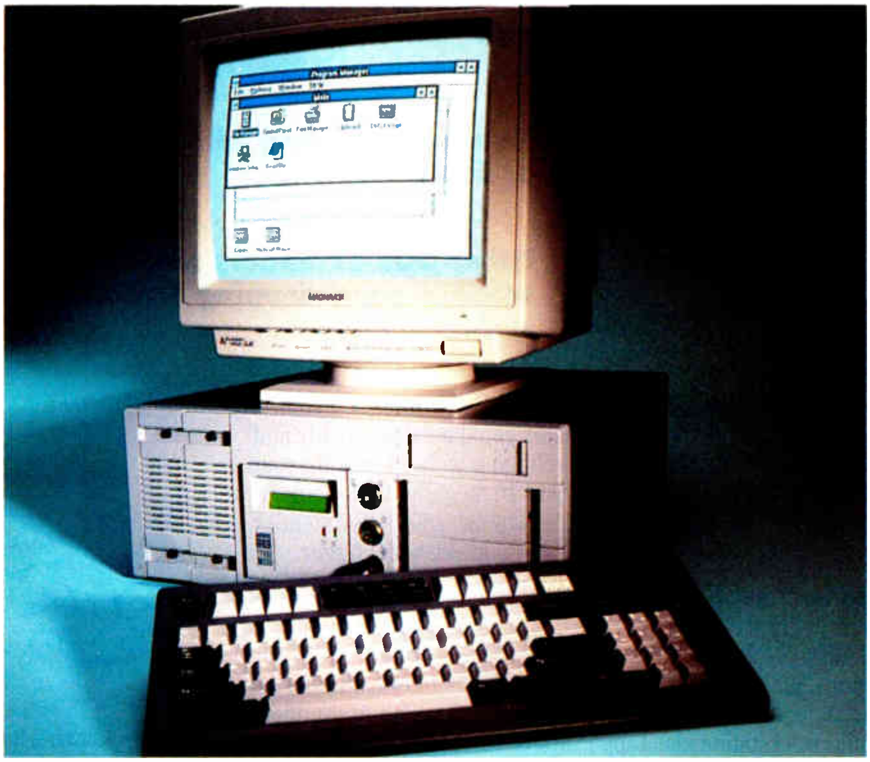
STEVE APIKI

Texas Microsystems' FTSA PC brings minicomputer-class fault tolerance to the humble PC

Reliability is the ultimate requirement for critical applications. No matter how fast, compatible, or capable a computer may be, it becomes just another "boat anchor" the moment power fluctuations, mechanical failures, or user errors take the system down.

The FTSA PC from Texas Microsystems is the first PC designed with high reliability and fault tolerance as primary considerations (FTSA stands for fault-tolerant system architecture). This computer integrates power protection and monitoring, subsystem redundancy, and data auditing into a ruggedly built but otherwise standard 386- or 486-based system.

Because many of its most sophisticated fault-tolerant features lie at the BIOS level, the FTSA PC will deliver full fault tolerance to only DOS applications or DOS-based environments (including Windows). Multiuser operating systems like Unix and NetWare are not supported, although you can share resources with a DOS-based network (e.g., LANtastic).



The front panel of the FTSA PC provides diagnostics messages through the LCD and access to redundant power supplies and disk drives.

Holistic Fault Tolerance

The FTSA PC employs three basic strategies for reducing downtime and data loss: redundant mechanical systems, data auditing, and power management. The real key to its design is the threading together of these components through a highly modified BIOS and some sophisticated proprietary hardware.

The rewritten BIOS serves as the dispatch point for the FTSA PC's protective hardware systems. From an application's (or DOS's) point of view, the FTSA PC looks exactly like any other AT-compatible system at the BIOS level. However, many system calls trigger additional action on the part of the FTSA PC to ensure data protection.

Three intelligent hardware systems form the basis for the FTSA PC's fault tolerance. The first is its mirroring SCSI hard drive controller, which handles the FTSA PC's redundant disks. Second, there is a processor that manages the power system. Finally, the FTSA PC includes a board dedicated exclusively to diagnostic and monitoring activities, which Texas Microsystems calls a *diagnostic coprocessor*. The diagnostic coprocessor monitors the bus, communicates with subsystems, and drives a front-panel diagnostic LED that displays messages.

Texas Microsystems has also placed a premium on reliable design in the system's standard PC components. Unfortunately, the case arrangement restricts expansion; the system accepts only a single 3½-inch floppy drive and the two SCSI hard drives that come with the unit.

Hard Drive Safeguards

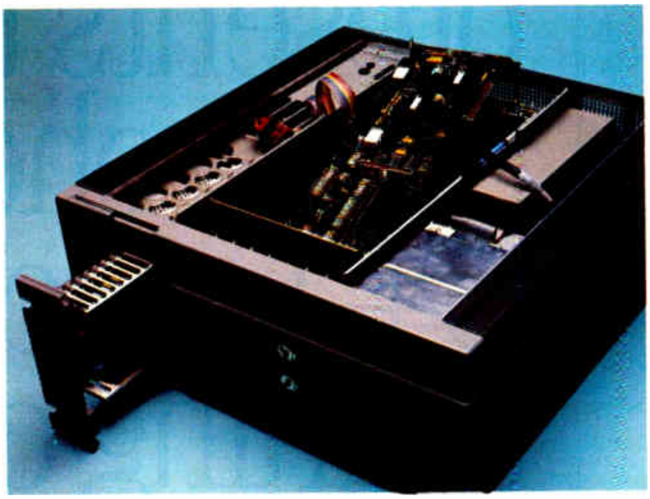
The FTSA PC's two SCSI hard drives are a mirrored pair. On my test system, each drive was 120 MB. As with any mirrored system, the secondary drive is always a duplicate of the primary drive, so you can recover from any single disk hardware failure.

If one disk should fail, the FTSA PC will continue to run, working off the surviving disk. However, you can't replace drives while the system is running. To replace a drive, you need to shut down the system, slide one drive out, and replace it with another. The drives are designed for easy replacement.

Mirrored drives can help you recover from hardware failures, but they can't protect your data from software problems or user errors. The FTSA PC handles this type of problem with a technique called *data-change auditing*. With this scheme, each change to the disk is recorded in an audit buffer.

The audit buffer is maintained by the system on a reserved partition on the hard disk. When disk write requests are passed through the BIOS, the FTSA PC updates both the data area and the audit list. You manage the audit buffer with a comprehensive utility package that is called ADS.

When any error occurs, you can use *rollback* to go to a known state. Rollback undoes the changes made to the disk; you just go back to a point before the data was corrupted. To help you keep track of the key points in the audit buffer, ADS lets you write markers (including comments) to the buffer.



The diagnostic coprocessor monitors the bus, drives the front-panel display, and provides an interface between the power-control module (behind the diagnostic card) and the rest of the system.

Naturally, all this data protection takes a noticeable toll on available storage. With both auditing and mirroring in place, I had only 80 MB to use within the 120-MB pair of drives.

Power Control and Monitoring

The FTSA PC guards against total power loss with a built-in uninterruptible power supply. But the FTSA PC's design also recognizes that more subtle power variations can cause serious damage to system components. The power management system ensures not just power, but clean power, for every component in the system.

The DC components draw their power from one of three possible sources: two redundant power supplies and a backup battery. The power supplies may be hot-swapped, and they too are designed for easy replacement. When any failure in the power system occurs—from the loss of a single power-supply component to the loss of both power supplies to the loss of external power—the power subsystem switches to one of its backup sources.

The power-control system monitors voltages on the system bus and adjusts power to match varying component loads as required. It dynamically adjusts to changes in external power.

There is no big red mechanical power switch on the FTSA PC. When you turn the front-panel keylock to the off position, you are actually launching a system shutdown script that flushes the cache and buffers before removing power from the system. This script runs on any shutdown, whether you turn the switch or power fails and the battery becomes exhausted. You can add additional commands to the shutdown script for your own application.

Reliable and Quick

A processor, system RAM, and a RAM cache are included on a card that mounts on a passive backplane. Texas Microsystems offers three CPU card configurations: 386SX, 386DX, and 486DX.

I tested an FTSA PC with a 25-MHz 386 processor, 4 MB of RAM, and a 64-KB cache. Although high performance is hardly this tank-like system's claim to fame, the FTSA PC held its own against more traditional, performance-oriented designs. On BYTE's low-level processor/memory benchmarks, the FTSA PC earned a 0.60 index, making it about 25 percent faster than the Compaq Deskpro 386/25e.

Although pure computing speed was unaffected by the company's emphasis on fault tolerance, disk performance lagged. Drive mirroring and audit-log maintenance tack a hefty overhead on to disk accesses. With ADS, you can choose your performance/safety trade-off by enabling or disabling the disk cache and selecting the cache write policy. Even in its fastest configuration (with a write-back cache), the FTSA PC scored only 0.49 on our disk benchmarks, slightly better than half the speed of the Deskpro 386/25e.

Who Needs It?

The FTSA PC is a comprehensive system designed from the ground up for fault tolerance. The preproduction unit that I looked at was still in a process of rapid revision, with upgrades occurring every few weeks. Just the same, it was in good shape.

This is not a machine for everyone. At over $8000 for a 25-MHz 386 system, the FTSA PC will appeal only to the few to whom system failure is intolerable. These few include those with downsize applications, as you'd expect. This group also includes those who have migrated business-critical paper-based systems, based on secure file storage, to single PCs.

It's the second group, the "upsizers," that will find the FTSA PC most indispensable. The system's BIOS-based design provides integration of fault-tolerant features at a very low level, but its reliance on operating systems and applications that use BIOS access will dull its appeal for those running downsize applications on NetWare, OS/2, and PC Unix networks.

For mission-critical single-user DOS applications, the FTSA PC is the perfect solution. This type of application may form only a small part of the PC universe, but the FTSA PC fills its niche admirably. ■

Steve Apiki is a BYTE technical editor with a B.S.E.E. from Rensselaer Polytechnic Institute. You can contact him on BIX as "apiki."

THE FACTS

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Cyrix's 486 in 386 Clothing

STEVE APIKI

Cyrix introduces its own 486 processor—and delivers it in a 386-pin-compatible package

Cyrix's Cx486 series marks the first introduction of a 486-compatible processor not manufactured by Intel. The announcement was not completely unexpected; Cyrix has been successful in its cloning of Intel's coprocessor line, and the company was known to be developing a 386 of its own. But Cyrix has gone one better by delivering a processor family with near-486 performance as replacements in 386 designs.

There are two processors in the series: the Cx486SLC, a 486SX compatible with a 16-bit external data bus that will fit existing 386SX designs, and an as-yet-unnamed full 32-bit 486SX compatible that will be pin-compatible with Intel's 386DX. Although pin-compatible with earlier generations, these units are not end-user upgrades. System vendors will need to make some (mostly trivial) modifications to existing 386 board designs to take full advantage of the Cx486s. Cyrix is keeping its customer list confidential but claims that "nine of the top 12" system manufacturers are working on Cx486 designs.

Both microprocessors are binary-compatible with the 486SX. They run the full 486SX instruction set, but they include only a 1-KB on-chip cache, versus the 8-KB on-chip cache of the 486SX. Like the 486SX, neither Cyrix processor includes an on-chip FPU, but the Cx486s work with 387 and 387SX coprocessors and don't require a 487SX. Each Cyrix processor is designed for low power consumption and includes direct support for suspend and resume—not found on either the 386DX or the 486SX.

Cyrix's new Cx486SLC is a 486SX processor that is pin-compatible with the 386SX.

What Makes a 486 a 486?

Are Cyrix's new processors 486 clones or enhanced 386s? They are clearly 486 clones: They run every series of instructions the same way a 486SX does. But since even Intel's 486SX and 386DX differ by only a few instructions and register definitions, the critical issue is performance. The Cx486 processors include most of the performance optimizations of the 486 (and some original enhancements); however, because they must run on existing 386 designs, they don't quite match the performance levels of the 486SX at equivalent clock speeds.

The 486SX includes just six instructions not found in the 386. Three of these are user instructions, and three are system instructions, primarily for cache management. There are also some differences in system flags and in the structure of the control registers. Each of these 486-exclusive features—the only features visible to software—are identical in the 486SX and Cx486 processors.

Most of the performance advantage the 486SX shows relative to the 386 lies in three key hardware features: on-chip cache, single-cycle execution unit, and burst-mode memory access. The Cyrix Cx486 does not support burst-mode memory access (neither does the memory bus used in 386 systems), but it includes a 1-KB on-chip cache, and it executes most core instructions in a single cycle.

Both Cyrix processors include a few unique performance optimizations. First, multiplications are handled by a hardware multiplier rather than by microcoded instructions. Second, the Cx486 processors do not generate additional wait cycles on unaligned memory accesses, as the 386 does; according to Cyrix, this gives the Cx486 processors a two-clock-cycle advantage on each unaligned memory read or write.

Although these chips are 486SX replacements, the addition of a 387 math coprocessor makes each an alternative to the 486DX. The 486DX should still run faster on floating-point-intensive operations, however, because its integrated FPU can run faster than an equivalent external device.

Small and Low-Power

Of the two new processors, the Cx486SLC has the more radical design. It comes in a 100-pin flat pack in two versions: a 25-MHz version that runs at 5 volts and a 20-MHz 3-V version.

The Cx486SLC is a 32-bit internal device. But because it must fit into existing 386SX designs, the Cx486SLC must make do with 16-bit external data and 24-bit external address buses. In addition to slowing data throughput, this constraint also limits the maximum memory in a Cx486SLC system to 16 MB, as with a 386SX.

Besides the smaller address and data bus, the Cx486SLC also has a multiplier

BYTE BENCHMARK RESULTS

Benchmark results place Cyrix's 486 designs between the 386 units they replace and full-blown 486 designs. These tests were run on preliminary Cyrix processors running in standard PC designs; performance on systems designed around the Cyrix 486s will probably be better.

Configuration*	Intel i486DX-33 Mylex	Cyrix 32-bit Dell	Intel i386DX-33 Dell	Intel i486SX-25 Toshiba	Cyrix Cx486SLC-25 AST	Intel i386SX-25 AST
LOW-LEVEL BENCHMARKS						
Sieve	111.34	79.85	45.89	83.43	57.48	25.47
Sort	11.70	9.99	5.45	8.78	7.11	2.92
Integer Math	506153.85	554652.82	387068.08	370053.55	436352.02	259788.48
Move Doubleword odd	227.73	154.42	125.84	172.96	115.40	116.32
Move Doubleword even	571.10	305.77	305.66	337.20	185.24	203.73

Configuration*	Cyrix Cx486SLC-25 AST	Intel i386SX-25 AST
APPLICATION BENCHMARKS		
Coprocessor	Cyrix 83S87	Cyrix 83S87
DOS Application Index	0.74	0.61
Windows Application Index	0.78	0.60

* **Mylex**: Mylex MAE486 system, 128-KB cache
Dell: Dell 333P, 32-KB cache, Cyrix 83D87 FPU
Toshiba: Toshiba T4400SX, no cache, no FPU
AST: AST Premium Notebook, no cache, Cyrix 83S87 FPU

unit and an on-chip 1-KB cache. The cache can be configured in either a direct-mapped or two-way set-associative organization. The Cx486SLC has seven signals not found on a 386SX; it maintains a compatible pin-out by assigning these seven signals to pins that were unused on the 386SX. Five of these seven signals are dedicated to cache control and maintaining coherency with external cache memory. The additional two pins are for the Cx486SLC's suspend and resume features.

Cyrix claims 0.5-milliwatt power consumption for the 25-MHz chip, compared to 1 mW for the 25-MHz 386SL. The Cx486SLC is also less demanding of power when active, requiring only 2 W (0.5 W less than an active 386SL). These figures are for the 5-V Cx486SLC; the 3-V version should require much less power.

On the Bench

I spent a day testing preliminary versions of both the 486SLC and the 32-bit 486SX clone at Cyrix. I ran performance benchmarks on each chip installed in off-the-shelf systems. The only difference between the Intel and Cyrix configurations was a program (supplied by Cyrix) that ran the on-chip cache on the Cx486s.

Because these are off-the-shelf systems, they don't include any BIOS or hardware modifications, which will make better use of the on-chip cache in OEM designs. Also, the preliminary processors I tested did not include full pipeline support. The table shows both low-level CPU and application benchmark results. The only tests on which the Cyrix processors did not fare very well were the BYTE Move benchmarks, which are extremely memory-intensive and primarily test memory architecture.

I also ran BYTE's full suite of application benchmarks on the Cx486SLC to test both compatibility and overall performance gain with the new processor. The preliminary Cx486SLC ran without noticeable compatibility problems through Microsoft Windows and 12 applications.

While end-user experience will be the only real test, my running of a dozen applications on a chip only one revision away from original silicon lends credence to Cyrix's claims of full 486SX compatibility.

Good News for Users

Undoubtedly, these new processors will lead to further legal wrangling between Intel and Cyrix. Cyrix, which designs chips but does no fabrication of its own, plans to license the designs for the Cx486 series to other manufacturers, further muddying the legal waters. Cyrix, while maintaining that the Cx486s do not infringe any patents, will rely on Intel patent licenses held by these licensees for legal protection against Intel.

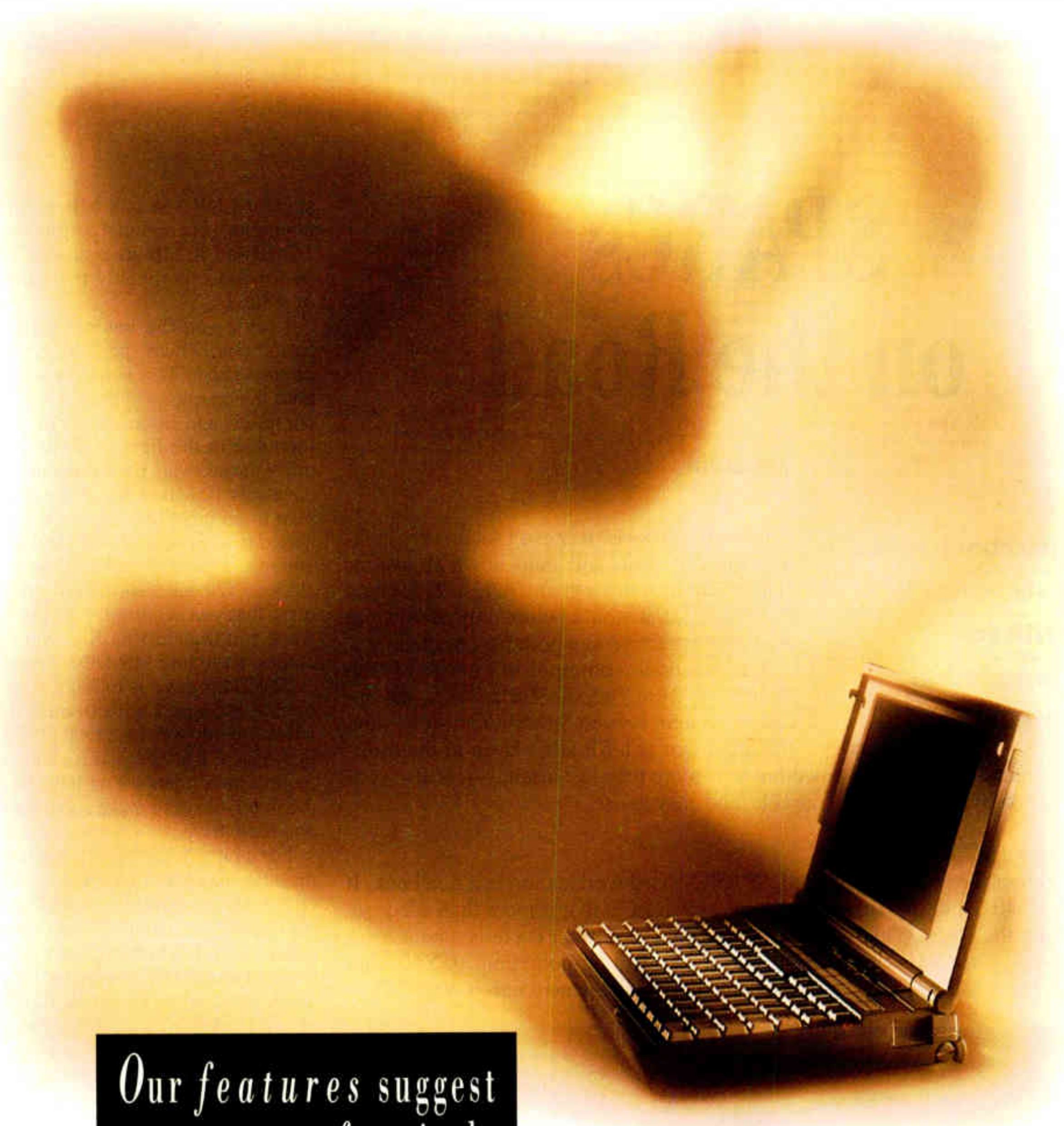
However the court battles are eventually resolved, Cyrix's introduction of these processors should spell good news for end users. System vendors should be able to deliver close to 486SX performance for very good prices by making small modifications to existing 386 designs. Cyrix's preliminary OEM pricing is also extremely competitive, which should lead to further price reductions. ■

Steve Apiki is a BYTE technical editor with a B.S.E.E. from Rensselaer Polytechnic Institute. You can contact him on BIX as "apiki."

THE FACTS

Cx486SLC-33
$119 (per unit in thousand-chip quantities)

Cyrix Corp.
2703 North Central Expy.
Richardson, TX 75080
(214) 234-8388
fax: (214) 699-9857
Circle 1078 on Inquiry Card.



Our *features* suggest a computer of entirely different *dimensions.*

Like other notebook computers, the AcerAnyWare™ series have 8½" x 11" footprints. But they leave a much bigger impression.

Because we've packed them with the features of desktop machines five times their size. The 386SX-based AcerAnyWare 1120NX, for example, gives you up to 60 MB of internal disk storage. 8 I/O ports (instead of the usual 5 or 7). A unique dual battery system that lets you change batteries without turning the system off. A full-function keyboard, to eliminate double keystrokes. A 10-inch backlit VGA display that's 22% bigger than most notebook screens. A carrying handle that flips down for a more comfortable keyboard angle.

Not to mention options like an internal Hayes-compatible fax/data modem. And an expansion chassis that lets you use your AcerAnyWare in local area networks—no matter what local area you're in.

Call 1-800-SEE-ACER in the U.S. and Canada and we'll tell you about the full range of AcerAnyWare notebooks. You'll think of them as desktop computers for very small desks. At a very small price.

Circle 10 on Inquiry Card (RESELLERS: 11).

SPARCs on the Road

BEN SMITH

The Sparcbook gives you truly portable Unix with full Sun workstation compatibility

Unix on a notebook? It doesn't sound very inviting. But if it boots and shuts down almost instantly and includes a great GUI, such as Open Windows 3.0, it would be not only usable, but also very attractive as a portable computer.

The notebook computer in question is the Sparcbook from Tadpole Technology, the operating system is from Sun Microsystems, and the processor is a SPARC. Even at the minimum configuration, this little powerhouse is more than just usable—it is also convenient, attractive, lightweight, durable, and easy to use.

The Hardware

The Sparcbook is a battery-operated, SPARC-based workstation in a notebook. It includes a 640- by 480-pixel monochrome sidelit LCD that is more than adequate for running the Open Windows/Open Look GUI to Unix. (There is also a color LCD model.) The CPUs are 25-MHz integer and floating-point units (CY601 and CY602). There is also a cache controller/memory management unit (CY604). The standard DRAM is 8 MB (a sufficient minimum), but optional configurations for 16 MB and 32 MB are available. The CPU performance is roughly the same as that of a Sun IPC.

Putting a little SPARC into your step is easier than ever now that Tadpole offers a portable version of the Unix-based workstation.

I reviewed the basic-configuration Sparcbook, which sports an 85-MB IDE internal drive. This is barely sufficient to hold the operating system, GUI, utilities, compiler, and libraries, all of which are included in the license. Even if you remove the software development tools, you have only 10 MB of free disk space. If you plan to do most of your work while connected to a network, the single disk may be enough. This low-end configuration includes a 720-KB/1.44-MB 3½-inch floppy drive that you can use for saving your old work and transferring files to other machines, including MS-DOS systems.

The alternative is to have your Sparcbook configured with two hard drives, which would give you a total of 125 MB of disk space. But space is a valuable commodity on a laptop. You have to give up the floppy drive to make room for the second hard drive.

For a laptop, the Sparcbook has an impressive number of I/O ports: an Ethernet (IEEE 802.3) interface, a PS/2-compatible Centronics (parallel) interface, a PS/2-compatible keyboard/mouse connector (six-pin mini-DIN), a port for an external VGA monitor, a 110- to 38,400-bps serial port (nine-pin mini-DIN), and an internal fax/communications modem (2400-bps communications/9600-bps fax).

The Sparcbook's keyboard is particularly noteworthy. First, the power-on switch is a large, green, recessed button above the keyboard. This switch does not turn the power off. After all, this *is* a Unix computer; the operating system needs to be shut down before the power is shut off. But more on power later.

The general keyboard layout is that of a Sun Sparcstation, but the arrow keys can also control the screen brightness and contrast. A special pressure-sensitive mouse key (near the upper right of the keyboard) can control the cursor if you are not using an external mouse. This technology is very usable, although the location of the pseudo–mouse keys on the Sparcbook is not the best. BYTE has found that the best location for the mouse key is at the *J* key, with the *S*, *D*, and *F* keys as the mouse buttons (see "Windows on the Road," March BYTE). Needless to say, not having to attach a mouse every time you want to use Open Windows is a great convenience for a portable computer.

All this fine hardware is enclosed in a 12- by 8½- by 2-inch magnesium-alloy clamshell case weighing just an ounce over 7 pounds including battery pack. It's small and light enough to use on the flimsy fold-down tray-tables in airline economy-class seating.

The Fuel Gauge

A true laptop like the Sparcbook needs to be able to run for several hours on its internal batteries. To conserve battery power, the computer and the low-level elements of the operating system have to play a number of tricks (e.g., turn off the drive when it isn't needed, shut off the display if it hasn't been used recently, and put the system to sleep if there hasn't been any activity at all). Although these tricks are not trivial even for MS-DOS systems, they are even more complex for Unix, a multitasking operating system. Tadpole provides an easy-to-use Open Windows utility for setting your preferences for when the screen, drive, and CPU should go to sleep.

The truly amazing element of all this is what happens when the power actually does run down—a situation that's very dangerous for most Unix systems. The Sparcbook continuously monitors the battery charge. (There is an Open Windows utility for viewing the battery "fuel gauge.") When the battery charge gets dangerously low, the Sparcbook saves an image of the system status to a special disk space and turns itself off.

The result is that you lose nothing. When you return power to the system (i.e., when you switch batteries or apply the charger), you're right back where you left off. All your applications, files, and even mouse and cursor are exactly the way you left them. When you force a power-off (by using the Alt-Esc-O key combination), the system image is saved in the same fashion.

Shutdown and power-up take less than 30 seconds. I have never seen any other Unix system on a laptop that even knows how to monitor the battery level, let alone shut down and power up the system in less than 3 minutes.

I have used Unix on portable computers. Although I work almost exclusively on Unix systems, I'd found that the long boot time and system shutdown meant that I didn't use the systems very much when I was traveling. A machine for the road is often used just to look up a piece of data or jot a note. Before the Sparcbook, it was much easier for me to run MS-DOS and emulate Unix with the MKS Toolkit. Now, I can have real Unix on the road.

Goodies Included

Unix is utility-rich. The Solaris operating system, which is shipped on the Sparcbook, is the rich implementation of Berkeley Standard Distribution Unix from Sunsoft. The Sparcbook also includes Open Windows 3.0 with all its window-based personal-productivity utilities, including a window manager, file manager, print manager, text editor, appointment calendar, clock, and mail interface. But Tadpole includes even more, such as the tools for monitoring and setting the battery conservation utilities and a tool for managing and sending faxes using the modem interface.

Even with all these utilities and tools, no Unix system alone can compete with MS-DOS for the number of available application programs. But the Sparcbook doesn't limit you to Unix; you can also run MS-DOS and Windows programs, because Tadpole bundles SoftPC.

Even though this emulation is done entirely with software, it is so complete that it lets you run Microsoft Windows 3.0 applications as well as all the standard stuff. If you are planning on using SoftPC, though, be careful what you specify for Sparcbook hardware options; you will want the floppy drive for loading those MS-DOS and Windows application programs.

The complete Unix manuals and the technical reference manual must be ordered as separate options, but the 300-page manual that comes with the system is very well written and covers all the basics of Unix and Open Windows, the utilities, system administration, and hardware.

The Review

Tadpole is not a new company. It is based in the U.K., with offices in Austin, Texas. The Sparcbook is likely to earn the company worldwide popularity, not only because this is the first laptop Unix system that lives up to its name, but also because Tadpole has done a quality job in looking at every important aspect of portable computing: power conservation, utilities, interfaces, durability, and usability on the road.

The only criticism that I have is minor: The keyboard action is uneven across the keys, the mouse key and buttons could be improved, and the case lacks a handle and the feet that would give it a more comfortable typing angle. Despite these few shortcomings, the praise that I have for the Sparcbook is unending. Tadpole's system offers most of the higher-end features available in the best of the PC-based notebooks; its performance, comfortable physical characteristics, and suite of on-board software tools really bring Unix to the world of portable computing with quality and style. ■

Ben Smith is a BYTE technical editor and the author of Unix Step-by-Step *(Howard W. Sams, 1990). You can contact him on BIX as "bensmith" or on the Internet at ben@bytepb.byte.com.*

THE FACTS

Sparcbook
with 8-MB DRAM, an 85-MB hard drive, and a floppy drive:
gray-scale, $4950
with 8-MB DRAM, a 120-MB hard drive, and a floppy drive:
gray-scale, $5800; color, $8000
with 8-MB DRAM and two 120-MB hard drives: gray-scale, $6700; color, $8900
with 16-MB DRAM, a 120-MB hard drive, and a floppy drive:
gray-scale, $8800; color, $11,000
with 16-MB DRAM and two 120-MB hard drives: gray-scale, $9700; color, $11,900
with 32-MB DRAM, a 120-MB hard drive, and a floppy drive:
gray-scale, $11,750; color, $13,950
with 32-MB DRAM and two 120-MB hard drives: gray-scale, $12,650; color, $14,850

Tadpole Technology, Inc.
8310 Capital of Texas Hwy. N
Austin, TX 78731
(800) 232-6656
fax: (512) 338-4462
Cambridge Science Park
Milton Rd.
Cambridge CB4 4WQ
U.K.
44-223-423-030
Circle 1077 on Inquiry Card.

NEWS

FIRST IMPRESSIONS

Active-Color Notebooks Arrive

If you have been waiting for great color displays on notebook computers, your wait may now be over. The Toshiba **T4400SXC** notebook incorporates an *active* color LCD, perhaps the last piece of the notebook computer's puzzle to fall into place.

The T4400SXC measures 11¼ by 8½ by 2¼ inches and weighs 7¾ pounds, including a nickel-cadmium battery pack. More on the battery pack later. In its standard configuration, it has a 25-MHz 486SX with 8 KB of internal cache memory, a 120-MB hard drive, a 1.44-MB floppy drive, and a beautiful 8½-inch diagonal thin-film-transistor, active-matrix color display. If you need the crunching power of a 486DX, the zero-insertion-force socket in the T4400SXC enables a simple change to the DX. The BYTE benchmarks showed that the SX-based system performs quite competitively, edging out some desktop machine functions and falling a little short in others.

The display provides VGA and Super VGA color (640 by 480 pixels) with 256 simultaneous colors from a palette of 185,193. The 60-to-1 contrast ratio of the display makes for excellent brightness and color saturation, so much so that there are no knobs to twiddle. Toshiba says that display capabilities have been carefully optimized and there is no need for external adjustment. Still, I'd like to have a knob or two just to satisfy my curiosity that the display is operating just right for me. By fixing the screen's power drain and by using the usual raft of power management features found in most portable systems, the notebook ends up with a battery life of at least 3 hours.

You can view the display from an extremely wide horizontal angle. While the vertical viewing angle is measurably less, the display pivots so you can adjust it for optimal viewing. Perhaps the biggest story is that the display-fabrication technology has managed to put over 920,000 working transistors on each thin-film display at yield levels sufficient to deliver quantities of machines at a reasonable price. Not included in the prototype I saw, but promised in the future, is a new Western Digital video controller chip. Toshiba says that this chip will perform Windows BitBlts in hardware to improve Windows performance, although I thought the display speed of the final prerelease system I reviewed was acceptable without it. But if you're really sensitive about cooling your heels for Windows activities, the new chip should help out.

The keyboard is, as usual, very nice. Toshiba seems to have found a good combination of feel, size, number, and spacing for its notebook keys. If you are desperate for your own full-size keyboard, a connector lets you use one or a separate 17-key numeric keypad.

While you're connecting to the outside world, you'll find the usual videoport that operates simultaneously with the notebook's display; a port you can use for a parallel printer, an external 5¼-inch floppy drive, tape backup, or a CD-ROM drive; a 150-pin expansion bus connector; and a PS/2 mouse port. There are dedicated slots for one of the Toshiba modem cards and a "credit-card" memory slot to increase RAM up to a total of 20 MB.

Some interesting notes about batteries and power management: Despite user-selectable automatic display and hard drive shutdown, CPU "sleep" mode, and other power-saving steps, *surprise*—an active color display and 486 use more power than passive color and lesser chips. Toshiba has been pioneering the use of nickel-hydride batteries in its notebooks. But because of the power requirements and the fact that nickel-hydride AA cells are 1½ times longer (in size) than nickel-cadmium AA cells, the company chose to go with a nickel-cadmium battery pack (C cells) to pack as much power as possible into the slim carbon-reinforced fiber-plastic case. Toshiba says that even in disk-intensive applications you should get at least 3 hours of operation per charge and "longer in normal use." You can fully recharge in about 90 minutes.

Accessories included with the T4400SXC are an AC adapter (3 by 6⅛ by 2 inches; 1⅜ pounds) and a custom clip for a Microsoft Ballpoint mouse that lets you close the cover without removing the mouse. Some of the extra-cost options include carrying cases, an external battery-pack recharger, modem cards, memory cards, keyboards, an external floppy drive, an external tape drive, a docking station, and even OS/2 1.21!

What's to complain about? Not much. A little bigger display, a little less weight, longer battery life, and the usual things that insatiable power users whine about (e.g., more RAM, more processing power, and more hard drive capacity). The suggested retail price of $7999 isn't cheap, but you usually have to pay a little extra to catch the leading edge. We may look back in a few years and consider the T4400SXC pretty mundane, but for now it's right at the top.

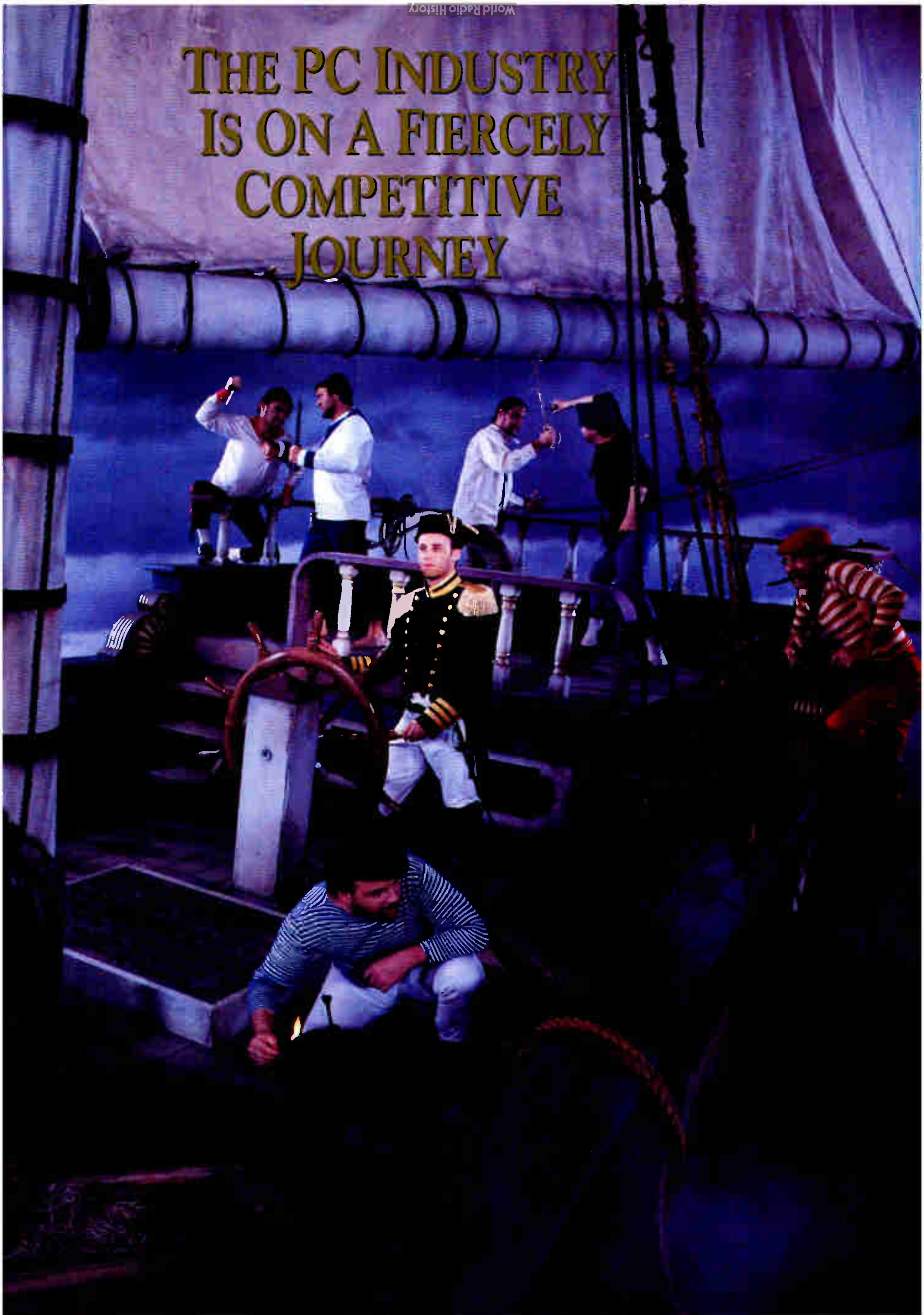
—Gene Smarte

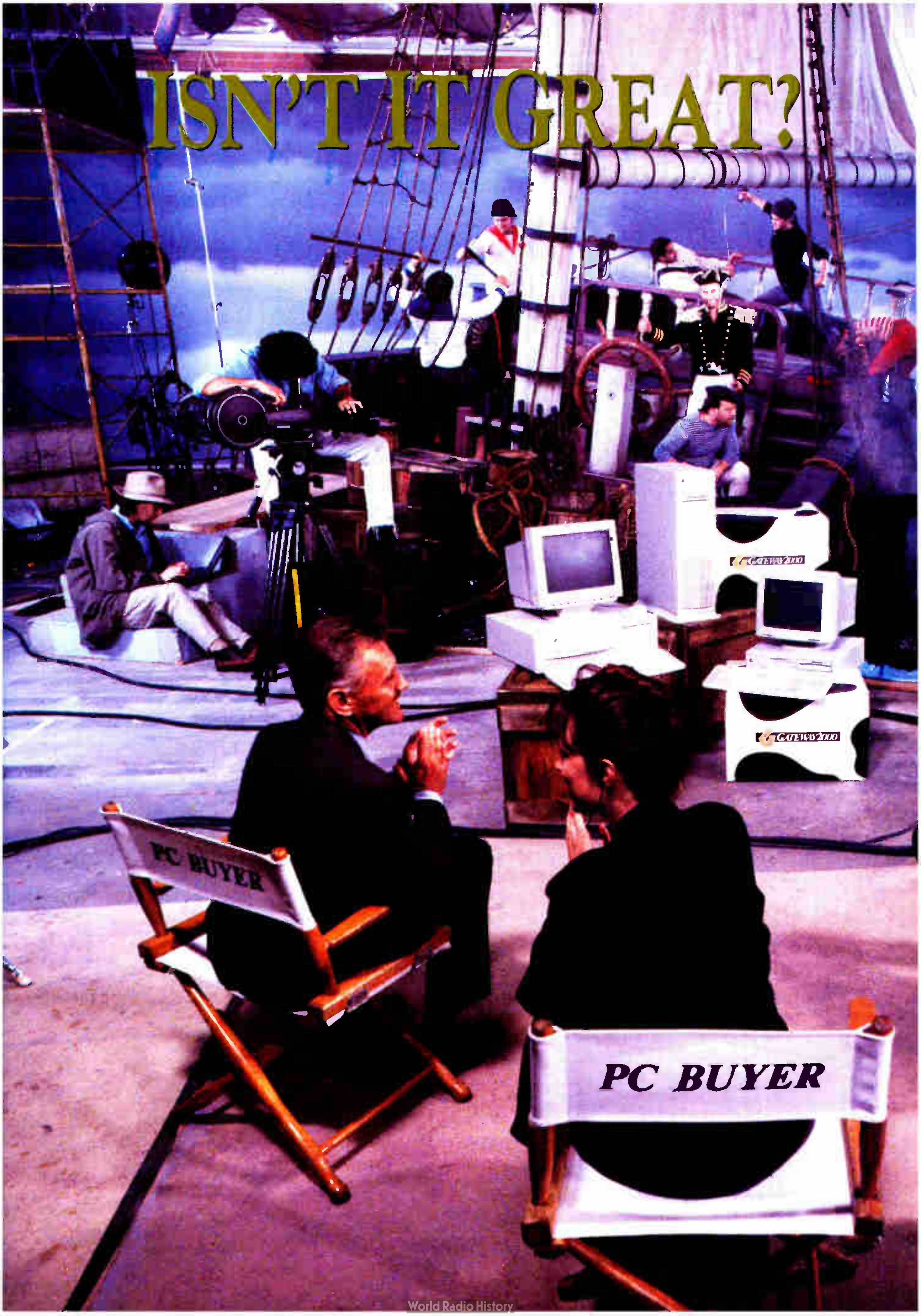
THE FACTS

T4400SXC
$7999

Options:
RAM cards: 2 MB, $399; 4 MB, $699; 8 MB, $1299
2400-bps modem, $279; 2400-bps MNP level 5 V.42bis modem, $359

Toshiba America Information Systems, Inc.
Computer Systems Division
9740 Irvine Blvd.
Irvine, CA 92718
(800) 334-3445
(714) 583-3000
fax: (714) 587-6034
Circle 1200 on Inquiry Card.


THE PC INDUSTRY
IS ON A FIERCELY
COMPETITIVE
JOURNEY


ISN'T IT GREAT?
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GATEWAY 2000
PC BUYER
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Hollywood's finest couldn't write a better drama than the one that is unfolding in the PC industry. The leading characters are embroiled in a competitive battle — and the struggle gets more intense by the month. One company slashes its prices. Another draws its sword and cuts prices, too. Then Gateway 2000 takes the wind out of their sails by continually coming out with unbeatable products and prices. We've been steering the industry toward greater value for years. And what's great about this story is *you're the winner* — especially with Gateway 2000!

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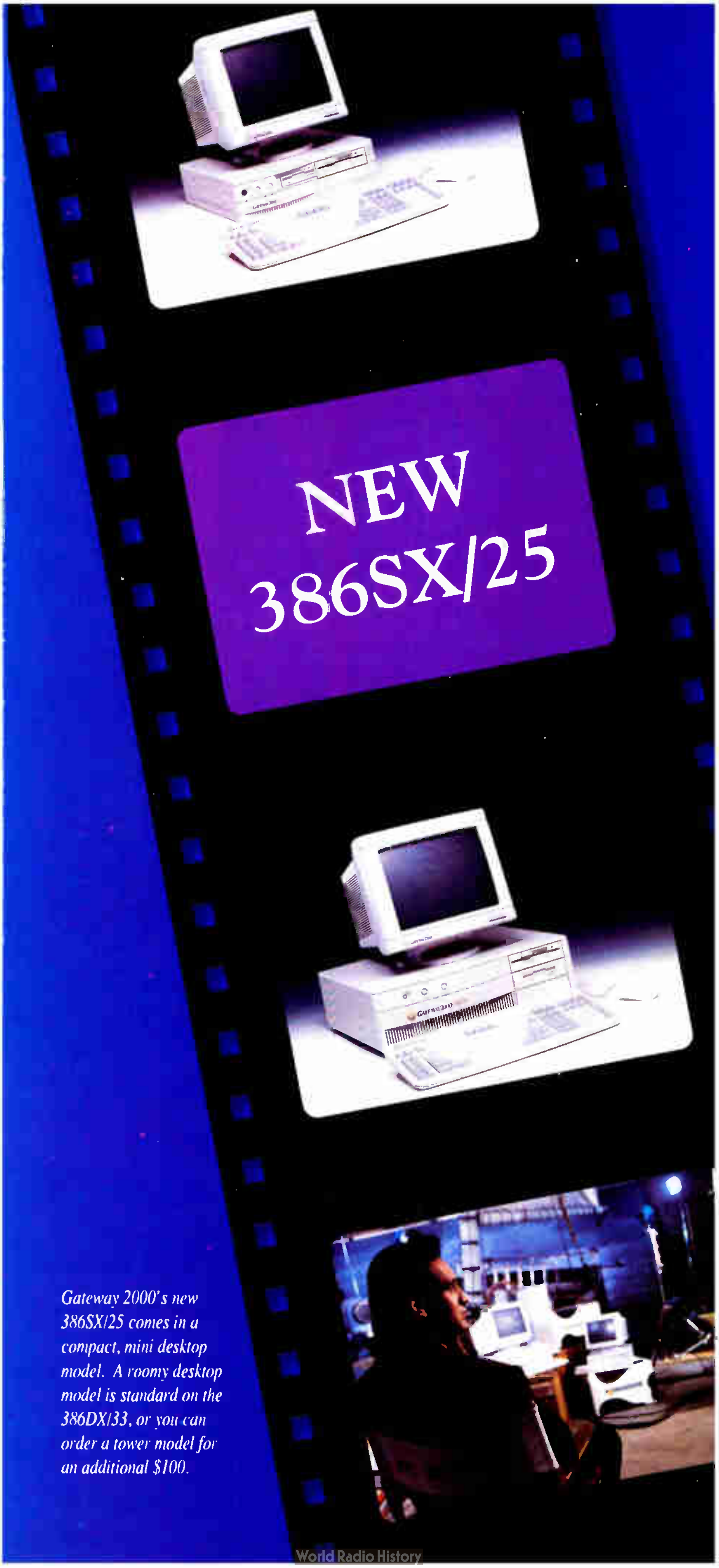
NEW
386SX/25
Gateway 2000's new
386SX/25 comes in a
compact, mini desktop
model. A roomy desktop
model is standard on the
386DX/33, or you can
order a tower model for
an additional $100.

FEATURE PRESENTATIONS
386 SYSTEMS

HERE'S YOUR TICKET: GATEWAY 2000 386 PCs

The two systems in our 386 product cast give you the best price/performance in SX and DX categories. We're introducing some new talent this month — a 25MHz 386SX. This system outperforms 16 and 20MHz 386SX machines, yet it's priced the same or better.

Our 33MHz 386DX, chosen by *Computer Shopper* readers as the Best Buy of 1991 in its category, is a box office favorite. This fully featured system offers the most value on the market for under $2,000.

25MHz 386SX

System Highlights: 4MB RAM ■ 80MB Western Digital® IDE hard drive with 32K read-look-ahead cache buffer ■ 16-bit VGA graphics with 512K ■ 14" Crystal Scan 1024 VGA color monitor, up to 1024 x 768 interlaced resolution ■ five 16-bit expansion slots available in standard configuration ■ mini desktop model ■ **$1,595**

33MHz 386DX

System Highlights: 64K SRAM cache ■ 4MB RAM ■ 120MB Western Digital IDE hard drive with 64K multi-segmented cache ■ 16-bit Diamond Speedstar Plus™ video card with 1MB ■ 14" Crystal Scan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ seven 16-bit slots on motherboard, one 32-bit memory slot and five 16-bit ISA slots available in standard configuration ■ desktop model is standard ■ **$1,995**

All Gateway 2000 systems come fully configured with all the features you want, including two diskette drives, a programmable 124-key AnyKey™ keyboard, a Microsoft® mouse, MS DOS® 5.0, the new Windows™ 3.1 and your choice of one application software option. See the back pages of this ad for complete configurations and information about software options, upgrades and peripherals.

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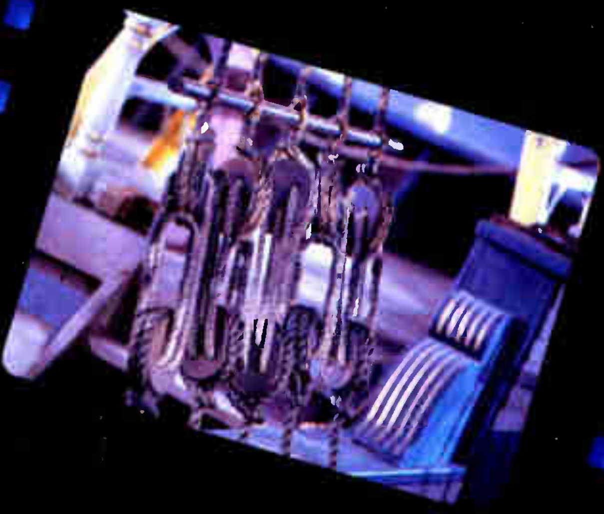
Gateway 2000's new 486SX/25 comes with 4MB RAM, a 200MB IDE hard drive and the ATI Graphics Ultra video card with graphics coprocessor for only $2,395.

NEW 486SX/25



EISA systems now come standard in a floor-standing tower model.

BLOCKBUSTERS: GATEWAY 2000 486 PCs

Making its debut some years ago, 486 technology has finally reached a price point at which it is upstaging 386 technology in value. Gateway 2000's 486 systems have always been star performers, but recent price reductions and the introduction of a 25MHz 486SX and two new DX2 systems make the Gateway 2000 486 line more appealing than ever.

25MHz 486SX

Besides being faster than any 386 machine on the market, the 486SX/25 is upgradeable to a 486DX2/50 if you need increased performance in the future.

System Highlights: 4MB RAM ■ 200MB Western Digital® IDE hard drive ■ ATI™ Graphics Ultra ■ 14" Crystal Scan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ desktop model is standard ■ **$2,395**

33MHz 486DX

The 486DX/33, our best-selling system until the DX2s came along, is still an excellent machine, especially with ATI video. Plus, it's upgradeable to a 66MHz DX2 when this CPU is introduced.

System Highlights: 64K cache RAM ■ 8MB RAM ■ 200MB Western Digital IDE hard drive ■ ATI Graphics Ultra ■ 14" Crystal Scan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ desktop model is standard ■ **$2,795**

50MHz 486DX2

This is without a doubt the fastest system at the most incredible price on the market today. The combination of a DX2 dual speed processor, an ATI Graphics Ultra video card and a fast IDE drive, made faster with RIDE BIOS, makes this machine worthy of an Academy Award. Our benchmarks show a 35% increase in performance over a 33MHz 486DX. Coretest benchmarks show large block disk-to-memory operations are over 30% faster with RIDE.

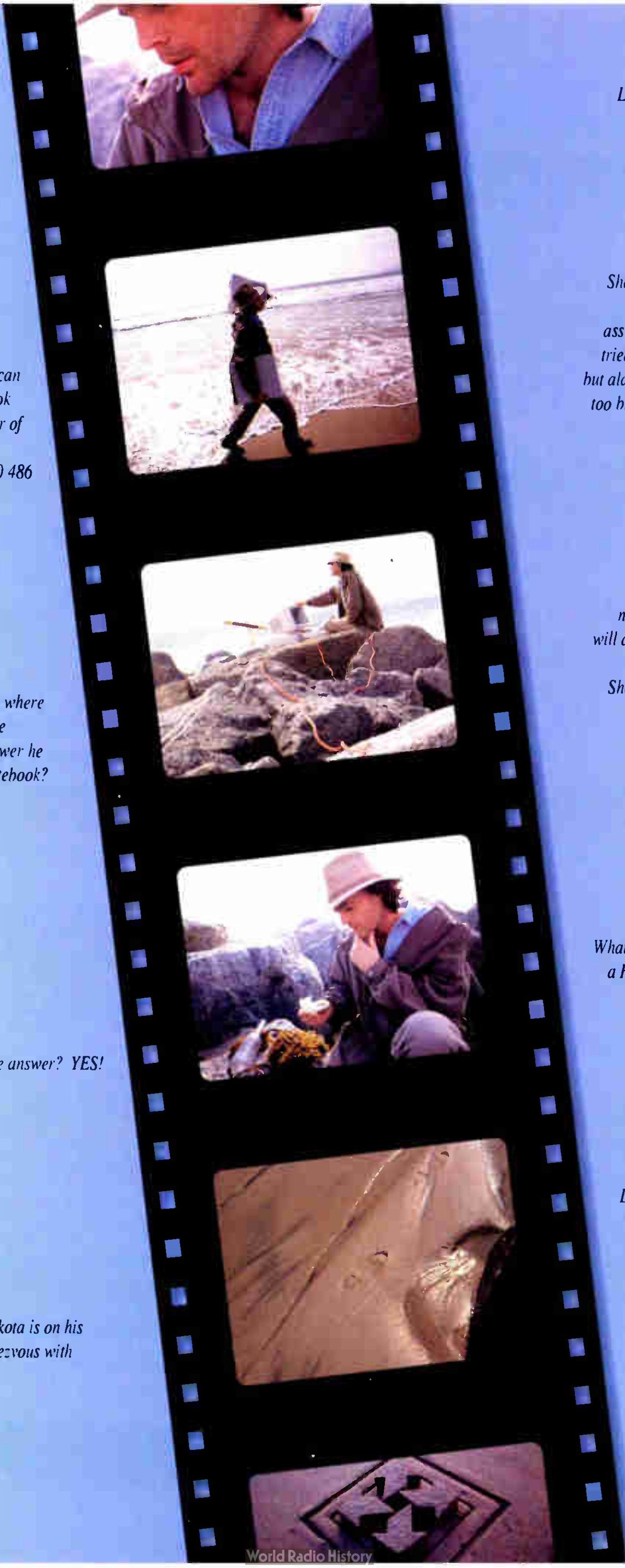
System Highlights: 64K cache RAM ■ 8MB RAM ■ 200MB Western Digital IDE hard drive with RIDE BIOS ■ ATI Graphics Ultra ■ 14" Crystal Scan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ desktop model is standard ■ **$2,995**

EISA SYSTEMS — 33MHz 486DX & 50MHz 486DX2

The 33MHz system is upgradeable to a 66MHz DX2 later this year.

System Highlights: 128K cache RAM ■ 8MB RAM ■ 340MB Maxtor® SCSI hard drive ■ 32-bit EISA SCSI controller ■ Diamond Speedstar Plus™ 16-bit VGA graphics ■ 14" Crystal Scan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ floor-standing tower model is standard ■ 486DX/33 EISA is **$3,795** ■ 486DX2/50 EISA is **$3,995**

GATEWAY2000
"You've got a friend in the business."



Dakota Smith is determined to save the world . . .

. . . if only he can find a notebook with the power of his beloved Gateway 2000 486 computer.

But where, oh where will he find the computing power he needs in a notebook?

Could it be the answer? YES!

In a flash, Dakota is on his way to a rendezvous with the Nomad.

Lexa Kirk faces a dilemma.

She needs to travel lighter on her assignments. She's tried notebook PCs, but alas — they're just too big and heavy for her needs.

Where's the notebook PC that will do the job and fit in her purse? She sighs wistfully.

What's this? There's a HandBook in her future?

Lexa is gone in a wink, setting off to discover her fortune.

COMING SOON: THE ULTIMATE NOTEBOOKS

Unknown to them, Dakota Smith and Lexa Kirk share a common bond. Both are relentlessly searching for the perfect portable PC, and this insatiable drive will ultimately cause their paths to cross.

Dakota is seeking a powerful notebook computer, capable of handling the complex mathematical calculations and large file storage required in his work as a field research scientist. Dakota's machine must also be small and lightweight with extended battery life. He never knows quite where his exhaustive expeditions will take him.

Lexa, on the other hand, is looking for a very small, lightweight notebook that won't be a burden in her travels as a freelance journalist. Something about half the size of most notebook computers would be ideal, but with a comfortable keyboard, good display, hard drive and the capability to transfer files back to her editor. Software would be nice, too.

The great distance between them closes as their thoughts merge at the same instant. "But where will I find such a machine?" As if by some mystical force, Dakota and Lexa simultaneously discover the directions to find the perfect portable PCs.

TO BE CONTINUED

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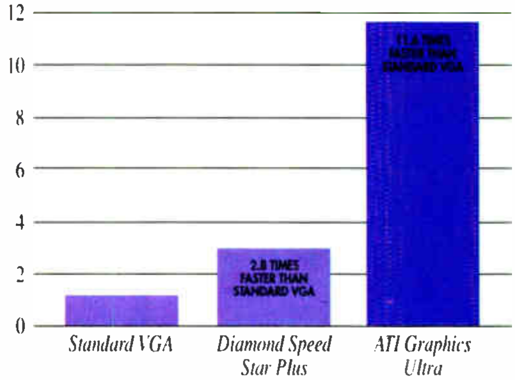

Figures computed on a 486DX/33 and provided by ATI Technologies Inc

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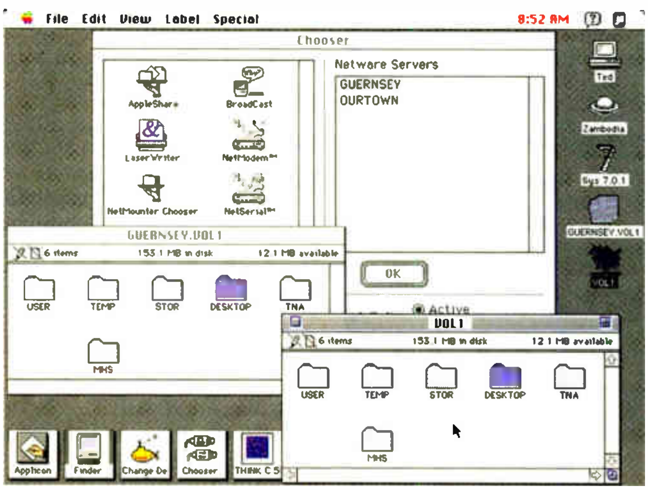
GLOBAL RELEAF

NEWS

FIRST IMPRESSIONS

Dayna's NetMounter Lets Macs Talk Directly to NetWare Servers

How does the shop that has an army of PCs and a smattering of Macs—with the whole arrangement lashed together by an Ethernet LAN—exchange files and share storage? For the PCs, you might purchase a cheap but fast AT-class PC and then spring for Novell's NetWare 286 (which costs about $2000) to provide file-server capabilities. That handles the PCs, but what about those Macs? One alternative is to add NetWare for Macintosh and a LocalTalk card to the server. However, a 20-user version of NetWare for Macintosh costs $900, and the LocalTalk card runs about $300 itself. Ouch!



NetMounter from Dayna Communications, at $99 a copy, is a handy alternative. It lets Macs connect directly to NetWare 2.2 and 3.11 file servers using Novell's IPX transport protocol over Ethernet. With NetMounter, NetWare servers appear as names in the Chooser, and you sign onto them with just a few mouse-clicks, just as you do with an AppleShare file server. Like AppleShare, the NetWare server appears on the Mac's Desktop as an icon, its subdirectories appear as folders, and the read/write access rights for both files and folders are fully enforced.

NetMounter does a lot of behind-the-scenes work to make NetWare server access look easy. Dayna implements an IPX protocol stack that manages translations between the Mac's native AppleTalk Filing Protocol and the server's IPX format. A special Ethernet driver router examines incoming packets and routes them either to the standard AppleTalk protocol stack or to Dayna's IPX protocol stack for processing.

I tried a beta version of NetMounter on a Mac IIci running System 7.0.1 and using a DaynaPort E/Z interface module to connect to BYTE's Ethernet network. The standard Installer application copies an RDEV and a Control Panel into the System Folder. Finally, it adds the low-level Ethernet driver into the System file. Once I rebooted, things operated as before, except that now I could connect to our NetWare file servers through NetMounter in the Chooser. Copying files to and from the NetWare volumes ran smoothly.

The NetMounter Control Panel lets you pick an Ethernet connection different from AppleShare, in case you're connected to shared resources on LocalTalk. It also lets you define DOS file extension mapping where, for example, a .TXT file appears as a MacWrite II text file, or an .XLS file appears as an Excel file. NetMounter has had a few minor glitches with System 7.0 Tune-Up and virtual memory, but these problems should be fixed when it ships.

In terms of cost, NetMounter makes sense when you have to connect a small group of Macs to a NetWare server. Also, for networks with multiple NetWare servers, NetMounter lets the Macs connect to all of them. A copy of NetWare for Macintosh would have to run on each server to supply the same level of Mac connectivity. Dayna gives price breaks for multiple copies of NetMounter, so NetMounter provides a cost-effective network solution.

—*Tom Thompson*

THE FACTS

NetMounter
single user, $99; five users, $399; 10 users, $599

Dayna Communications, Inc.
50 South Main St., Fifth Floor
Salt Lake City, UT 84144
(801) 359-9135
Circle 1201 on Inquiry Card.

Networking the Windows Clipboard

Networks Connect 1.0 from Symbiotics slides a TCP/IP-based peer network underneath Windows and uses it to make the Windows Clipboard network-aware. If I copy a range of cells from Excel, you can transfer my Clipboard to yours via Connect and then paste a copy of the cells into Word. You can also paste-link the information so that my instance of Excel will dynamically update your instance of Word across the network.

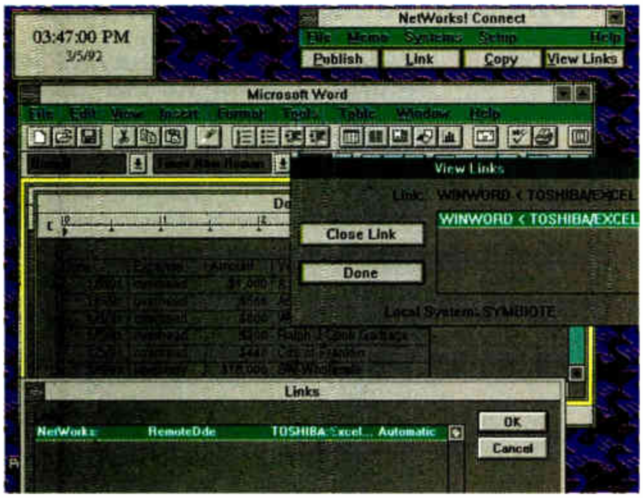
If I choose to publish the contents of my Clipboard as a named resource, Connect writes the Clipboard information to my disk. Later, you can scan for and acquire the resources I've published. Named resources, which resemble the edition files of Mac System 7.0's Publish/Subscribe, free you from a real-time dependence on the contents of my Clipboard. This ability to publish named resources is Connect's nicest feature.

The two forms of networked sharing—simple Clipboard transfer and DDE linking—correspond to the same operations in stand-alone Windows. Because Connect can expose the Clipboard to the outside world, it offers security. If I don't want you snooping around on my Clipboard, I can prevent you from doing so.

When applications link, a Connect proxy on one end of the link routes DDE traffic across the network to the Connect proxy on the other end. You can monitor active links from Connect's tool window (see the screen). Even though Windows 3.1's Object Linking and Embedding uses DDE as a transport, Connect does not enable remote OLE in version 1.0, which supports the Link Clipboard format but not the newer ObjectLink format that Windows 3.1 OLE applications use. Symbiotics will

NEWS

FIRST IMPRESSIONS



probably have synchronized Connect with Windows 3.1 by the time you read this.

Connect provides simple messaging and file transfer tools. The file transfer tool offers both "push" and "pull" modes. You can push a file onto another machine's INBOX directory, or you can pull files from another OUTBOX directory—assuming you configure both instances of Connect to allow file transfer.

All this excellent magic requires a good deal of stage-setting. Symbiotics bundles FTP Software's TCP/IP stack (70 KB) and adds its own TCPTSR (50 KB), which manages connections and queues messages. Shoehorning all this into upper-memory-block space is tricky, if not impossible. Then you have to set up a Connect name server as well as populate its database with the names and IP addresses of all the machines that will run Connect.

There is a reason why Connect works this way. It's one of the first commercial fruits of Networks Developer, a toolkit for building systems of communicating objects for heterogeneous networks of DOS, Windows, and Unix workstations. Unfortunately, the cross-platform capabilities that Developer-built applications enjoy won't be obvious to most users of Connect. Smoother integration with the underlying network operating system will almost certainly be required to make Connect a mainstream success.

Symbiotics plans to streamline Connect with the next release of FTP Software's kernel, which will run as a DLL. But the option to use native transports and node names, rather than requiring a completely separate network layer for Connect, would be an even bigger help.

Despite its burdensome infrastructure, Connect should do well. Integrators will write scripts to exploit the remote DDE capability. Casual users will appreciate the ability to publish named resources directly from the Windows Clipboard.

—Jon Udell

THE FACTS

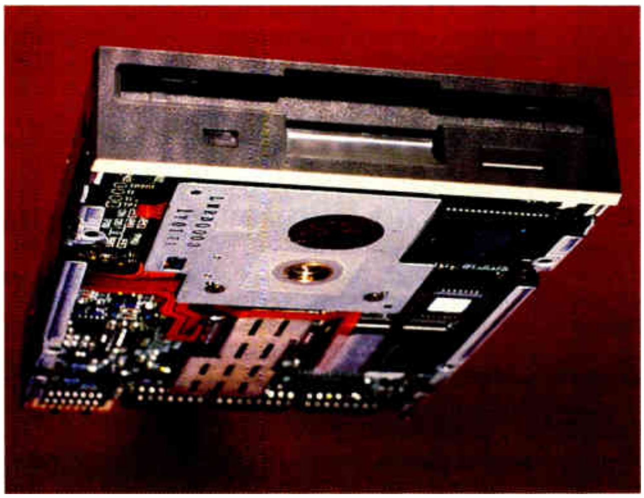
Networks Connect 1.0
two-user starter kit, $595

System requirements:
Windows 3.x and NetWare (other networks may work, but they lack specific support).

Symbiotics, Inc.
875 Main St.
Cambridge, MA 02139
(617) 876-3635
fax: (617) 876-0157
Circle 1202 on Inquiry Card.

Floptical Arrives At Last, and It Works

There's finally some good news to report on the status of very high density (VHD) floppy drives: The 20-MB **1325VM Floptical** drive from Insite Peripherals is available at last, and it was worth the wait.



Floptical is a new kind of beast, a hybrid of a floppy drive, a hard drive, and an optical disc. As with floppy drives, the recording media are removable 3½-inch magnetic disks, similar to the ones you use today. Like a hard drive, it has fast access: The average speed is 80 milliseconds, and the track-to-track seek time is just 18 ms. Also like many hard drives, it uses a SCSI connector, so the data throughput can range up to 1.5 MBps.

The real breakthrough is Floptical's laser-optic tracking, which gives it finer track pitch. Floptical uses closed-loop servo-positioned heads that read rings that are preprinted on special disks. The result is that Insite can cram 1245 tracks per inch onto the medium, compared with 45 to 135 tpi for floppy disks. The linear density is higher, too, at nearly 24,000 bits per inch (versus 17,000 bpi for high-density drives).

Although my first installation was an OEM unit, it couldn't have been easier. I stuck the 8-bit SCSI card in a free bus slot, removed my existing B drive, and put Floptical in its place, connecting it to the SCSI port with a keyed ribbon cable. I didn't have to set any jumpers or switches on the interface, nor did I have to add a software driver to my CONFIG.SYS file.

When I booted up my system, Floptical installed itself as my D drive. I hadn't changed my CMOS setup to reflect that the B floppy drive was no longer there; otherwise, Floptical would have installed itself as B. I formatted three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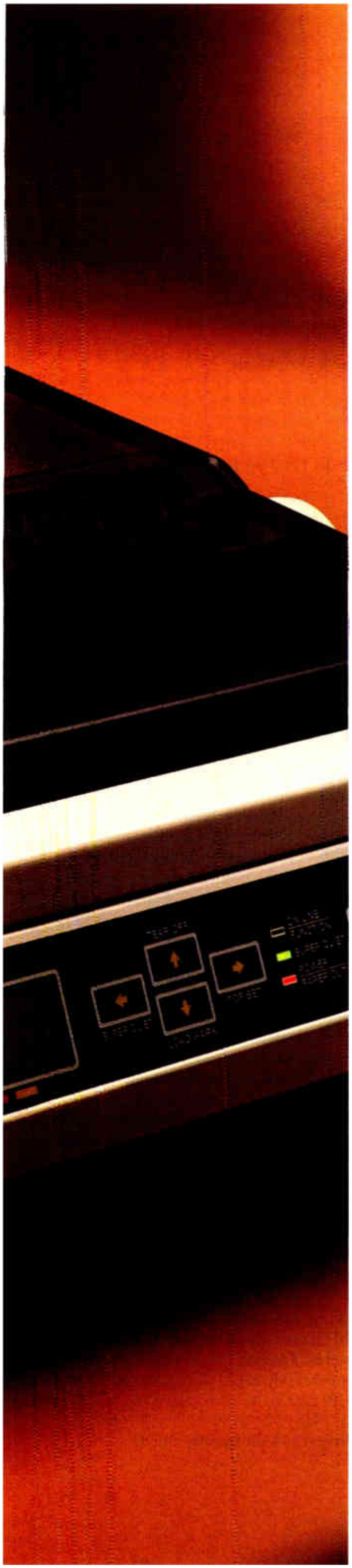

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disks: one as 720 KB, one as 1.44 MB, and one, using the special Floptical medium, as 21 MB. The system was able to tell what kind of disk was installed and formatted it appropriately. The lower-capacity disks worked perfectly in my regular floppy drive.

Before you can get DOS to format a VHD disk, you have to install a patch called FMTFIX that is supplied by Insite. The patch loads as a 600-byte TSR program. Floptical media can be formatted with a choice of file-allocation-table types. A 12-bit FAT is backward compatible with DOS, so you can use the medium as a bootable DOS disk. The more efficient 16-bit FAT offers the same total capacity, but it can store more files because short files don't waste as much sector space. This format isn't bootable, but it's fine if you're using the medium only for backup.

My only reservation about Floptical was its slow start-up speed. This is a minor drawback. Insite argues that with a Floptical installed as your A drive, you can keep using your existing medium *and* be able to back up an 80-MB hard drive onto four disks. This is a persuasive idea, and, best of all, it works.

—*Andy Reinhardt*

THE FACTS

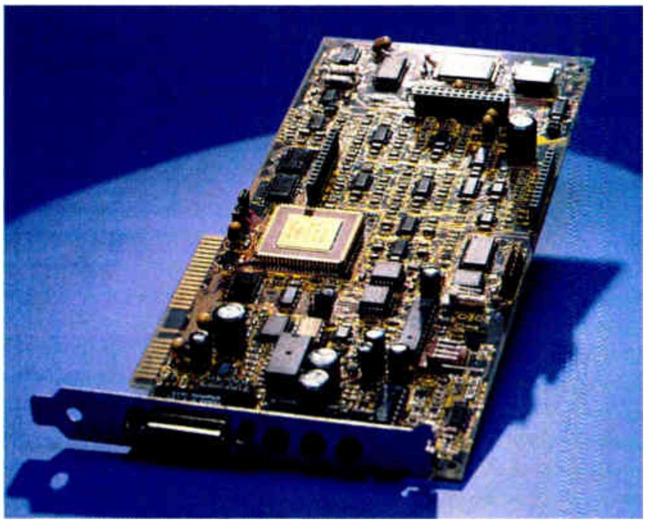
1325VM Floptical
(contact dealer for price)

Insite Peripherals
4433 Fortran Dr.
San Jose, CA 95134
(408) 946-8080
fax: (408) 946-4403
Circle 1203 on Inquiry Card.

The Sound of Gold

The flow of MPC-compatible software now coming to market has hit a snag: the sound barrier. Even though the MPC specification covers advanced technology like CD-ROM and video overlay, the first compatible audio boards leave much to be desired in the areas of sound quality and music quality.

Ad Lib's proposed solution to this is its Gold Stereo Sound Adapter. I had a chance to plug a prerelease version of the **Ad Lib Gold 1000** card into a Tandy 4033LX multimedia system. The Gold 1000 is an 8-bit ISA board that incorporates digital audio record and playback, music synthesis, MIDI, and joystick control. But it isn't what the Gold 1000 does that sets it apart—it's how it does it. The Gold 1000 sets several new quality standards over its predecessors, and it's here that it makes its mark.



The first plus is its on-board music-synthesis chip. It is still made by Yamaha and is still based on somewhat outdated FM technology, but FM has proven to be inexpensive and easy to implement. This new chip pumps out up to 20 simultaneous voices of synthesized music in stereo, and with a selection of instrument sounds much broader than the original FM sound chip could offer. The new Yamaha chip has a compatibility mode that lets it behave like the FM chip on previous Ad Lib and compatible boards, so most older software will still run.

The Gold 1000's digital audio capabilities have been enhanced as well. There are two independent channels of 12-bit digital audio, which can record and play back 8-, 12-, or 16-bit files at bit rates of up to 44.1 kHz. The two channels can be used together to produce stereo, or they can be separated so that, for example, one can play a digitized musical score while the other offers running verbal commentary.

The board I evaluated came with some fairly impressive demonstrations. Something I found interesting about them, however, was the liberal use of combined FM synthesis and digitized audio. FM has a distinctly synthetic sound to it; many of the tunes used digitized drums or strings to add punch and realism. When digitized audio is added, it tends to take some of the flatness out of the FM sounds.

The Ad Lib Gold 1000 will have a number of hardware options, including daughtercards for surround sound (i.e., echo and reverberation effects) and telephone answering.

Where "serious" music applications—business presentations, educational multimedia, and so on—are concerned, this card will be competing against others based on technologies superior to FM. Of these, audio boards based on pulse-code-modulation sampled sound offer the greatest realism and fidelity. FM's advantages are its low cost and the number of distinct instrument sounds that can be packaged on a single product (the Gold 1000 boasts over 600). Whatever wins, I'm happy to see the audio side of PC multimedia growing rapidly out of its video-game roots to join the grown-up world. ■

—*Tom Yager*

ITEMS MENTIONED

Ad Lib Gold 1000
$299.95; SCSI adapter kit, $79.95; surround-sound module, $89.95; telephone answering card, $99.95

Ad Lib, Inc.
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Elegance at Your Desk

The Elegance ZXP systems feature a motherboard with a zero-insertion-force processor socket that accepts Intel's single-chip upgradable 486SX and 486 processors. The ZIF socket lets you upgrade your system by flipping a lever to change the chip.

Available as a compact five-bay desktop or a seven-bay tower computer, the basic Elegance ZXP is a 16-MHz 486SX unit with 4 MB of RAM (expandable to 32 MB), 64 KB of read/write cache, and a CMOS BIOS with password security. It has one 8-bit and six 16-bit expansion slots, an IDE hard drive and floppy drive controller, and a 52-MB IDE hard drive. The unit comes with a 14-inch VGA color monitor, parallel and serial ports, a 101-key keyboard, DOS 5.0, QBasic, Windows 3.0, and a mouse.

Price: Basic unit, $2199.

Contact: Northgate Computer Systems, Inc., P.O. Box 59080, Minneapolis, MN 55459, (612) 943-8181; fax (612) 943-8338.

Circle 1271 on Inquiry Card.

Northgate's Elegance ZXP system provides easy upgradability.

NoteBrick Takes CAD Out of the Office

A notebook computer for Windows, CAD, and desktop publishing, the NoteBrick is built around a 33-MHz 386 with 32 KB of cache memory. You can configure the DOS-, Unix-, and OS/2-compatible unit with 4 or 16 MB of RAM.

The 8.7-pound NoteBrick features an 80-MB hard drive, a 1.44-MB floppy drive, a 9-inch backlit LCD, and support for an external VGA color monitor. The hard drive is expandable to 160 MB via the included SuperStor data-compression software, which also doubles the capacity of the floppy drive to 2.8 MB.

Interfaces include serial and parallel ports, an external keyboard port, and an external floppy drive port. An optional portable expansion module holds two ISA half-length cards and has two serial ports and a parallel port.

Price: $2995; expansion module, $295.

Contact: Ergo Computing, Inc., 1 Intercontinental Way, Peabody, MA 01960, (800) 633-1925 or (508) 535-7510; fax (508) 535-7512.

Circle 1272 on Inquiry Card.

Notebook Has Expansion Possibilities

Based on Intel's 386 CPU running at 33 MHz, the NB3300 notebook computer comes with a 100- or 120-MB hard drive. Its 4 MB of RAM is expandable to 16 MB, and it has 32 KB of direct-mapped cache memory. A 100-pin expansion port lets you connect the unit to a docking station, whereby you gain two 16-bit half-size expansion slots, two serial ports, a parallel port, a keyboard port, and a color VGA monitor port.

The NB3300's backlit, supertwist VGA LCD has a resolution of 640 by 480 pixels in 32 shades of gray. Standard interfaces include serial and parallel ports, as well as ports for an external VGA monitor and an external PS/2 device.

Price: Starts at $2450; docking station, $250.

Contact: PC-Ease, Inc., 5813 Main St., Suite 10, Buffalo, NY 14221, (800) 472-3273 or (716) 626-0315; fax (716) 626-1541.

Circle 1273 on Inquiry Card.

Slim Profile and Power Travel Together

The SlimPro 2¼-inch-high desktop system weighs about 10 pounds for easy portability and fits snugly under your monitor. Configured with a 25-MHz 386SX AMD CPU and 1 MB of RAM (expandable to 16 MB), the SlimPro has a built-in IDE controller, a 1.44-MB floppy drive, a VGA graphics board with 1 MB of video RAM, a parallel port, and two serial ports. Two standard-size slots hold the video card and a LAN or modem card. There is space for a hard drive.

Price: Starts at $425.

Contact: Addtech Research, Inc., 41332 Christy St., Fremont, CA 94538, (510) 623-7583; fax (510) 623-7538.

Circle 1274 on Inquiry Card.

486 with VGA on the Local Bus

With its 1 MB of VGA RAM on the local bus, the PCS 486-33 Local Bus VGA computer is a mid-size tower system with 8 MB of RAM (expandable to 32 MB on-board). The unit includes 64 KB of write-back cache (expandable to 512 KB), zero wait states, dual floppy drives, a 200-MB hard drive with 32 KB of cache, and a 14-inch noninterlaced Super VGA color monitor. The computer is compatible with OS/2 and Xenix.

Price: $2799.

Contact: First Computer Systems, Inc., 6000 Live Oak Pkwy., Suite 107, Norcross, GA 30093, (800) 325-1911 or (404) 441-1911; fax (404) 441-1856.

Circle 1275 on Inquiry Card.

Multinetwork Laser Printer

The QMS-PS 1700, a 17-ppm multinetwork laser printer, combines Multi-Res technology with microfine toner to let you select 300- or 600-dpi output. The printer serves any combination of 20 PCs, Macs, and Unix and DEC machines running NetWare, EtherTalk, TCP/IP, or DECnet.

Powered by an 80960CA 25-MHz RISC-based processor, the QMS-PS 1700 has 8 MB of RAM (expandable to 32 MB via SIMMs). The additional RAM increases the input buffer space for resident job spooling, but you can also configure it as a font cache or for downloaded font storage or forms and logo storage. Resident printer languages include PostScript and emulation for Hewlett-Packard PCL 4 and HPGL 7550. With the optional Ethernet interface with the DECnet protocol installed, LN03+/ANSI is available. An Emulation Sensing Processor analyzes the incoming data stream from four available interfaces and selects the appropriate language.

Price: Base configuration, $7995.

Contact: QMS, Inc., 1 Magnum Pass, Mobile, AL 36618, (800) 523-2696 or (205) 639-4447; fax (205) 633-0013.

Circle 1276 on Inquiry Card.

The QMS-PS 1700 laser printer can serve 20 computers.

Smooth Animation Video

By means of fast disc spinning, NEC's multimedia-ready M Series of Intersect CD-ROM readers attain average access times of 450 ms for the CDR-36M and 280 ms for the CDR-73M and CDR-83M. Data transfer rates are also improved by this technique, with a rate of 150 KBps for the CDR-36M and 300 KBps for the CDR-73M and CDR-83M. Each CD-ROM reader has 64 KB of cache memory.

A portable reader, the CDR-36M has a user-selectable ID of 0 through 7 and attaches to most IBM-compatible portable computers via the company's parallel-to-SCSI adapter. A SCSI Interface Kit includes audio drivers.

An external desktop unit, the CDR-73M has a dust brush that cleans the laser read head. The CDR-83M is an internal half-height unit. The SCSI Interface Kit for each unit includes audio software and headphones.

Price: Starts at $449 for the portable reader.

Contact: NEC Technologies, Inc., 1255 Michael Dr., Wood Dale, IL 60191, (800) 366-0476 or (708) 860-9500.

Circle 1277 on Inquiry Card.

Versatile Floptical Disk Drive

A 20-MB Floptical disk drive, the Viper Drive gives you a dual-purpose floppy drive system that reads and writes standard 1.44-MB Mac floppy disks as well as 20-MB Floptical disks. The drive automatically senses which type of disk it's working with, so you can use the disks interchangeably.

The SCSI storage device features push-button SCSI ID selection, twin SCSI ports that let you daisy-chain SCSI devices, and switchable SCSI bus termination. Available as an internal drive for the Mac Quadra 900 and as an external unit for Macs with a SCSI port, the Viper Drive supports Floptical partitioning and password protection.

Price: Internal drive, $645; external drive, $745.

Contact: Second Wave, Inc., 9430 Research Blvd., Echelon II, Suite 260, Austin, TX 78759, (512) 343-9661; fax (512) 343-9663.

Circle 1278 on Inquiry Card.

Flatbed Color Scanner

A flatbed color scanner, the 600-dpi, 24-bit Animas Synergizer-2 uses a light-source alignment for color recognition. Combining red, green, and blue light sources with two gamma correction curves, the scanner can reproduce 16 million colors, 256 levels of gray, or any combination of detailed line art and half-tone patterns.

The Synergizer-2's three-pass scanning approach lets you set the zero point anywhere on the scanning pass, further enhancing the color recognition accuracy. The built-in SCSI connection allows a plug-and-play connection to Macs.

Price: $1995.

Contact: Mouse Systems Corp., 47505 Seabridge Dr., Fremont, CA 94538, (510) 656-1117; fax (510) 770-1924.

Circle 1279 on Inquiry Card.

A Mouse with Adjustable Resolution

The System Mouse (Serial Version) is a three-button optomechanical mouse with a serial interface. Dynamic tracking lets the mouse adjust resolution from 290 dpi to 1450 dpi based on the speed of your hand. The mouse is Microsoft, Mouse Systems, and Windows compatible.

Price: $29.95.

Contact: IMSI (International Microcomputer Software, Inc.), 1938 Fourth St., San Rafael, CA 94901, (415) 454-7101; fax (415) 454-8901.

Circle 1280 on Inquiry Card.

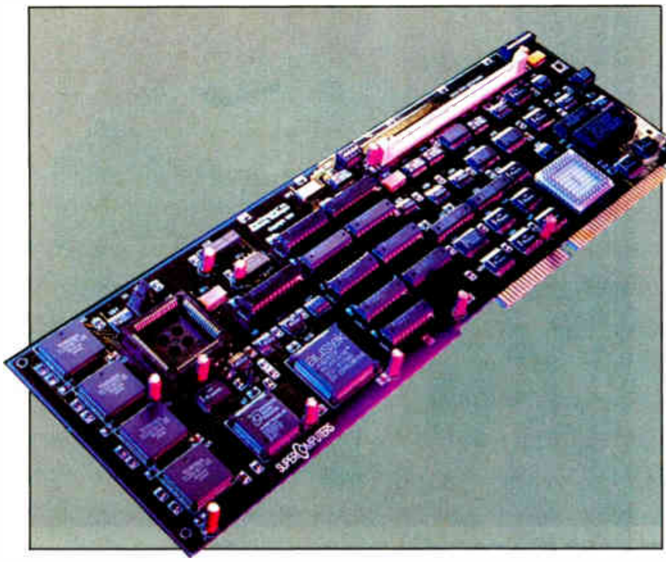
Put 386SX Power in Your 286 Computer

The Super SX upgrade cards for the Compaq Deskpro 286/12 and AST Premium/286 machines give these systems the power of 386SX units. The cards include an AMD 386SX processor with a clock speed of 25 MHz. A 16-KB two-way associative cache is provided for the ROM BIOS, video BIOS, and data; an additional 64 KB is available as an option.

The Super SX cards can accommodate up to 8 MB of additional RAM via memory modules. Once the memory is installed, the card automatically recognizes it.
Price: $598 (Compaq interface cable, $40).
Contact: SuperComputers, Inc., 8575 Willows Rd., Redmond, WA 98052, (206) 881-7500; fax (206) 881-5015.
Circle 1281 on Inquiry Card.

Feature-Full VGA Card

A VGA card that uses application-specific IC technology and operates in 8- or 16-bit mode is available from JDR Microdevices. The card supports resolutions of 800 by 600 pixels in 16 colors, 640 by 480 pixels in 16 colors, and 320 by 200 pixels in 256 colors and is compatible with analog and multisync monitors. Features include automatic mode switching for VGA, EGA, CGA, MDA, and HGC displays.
Price: $49.95.
Contact: JDR Microdevices, 2233 Samaritan Dr., San Jose, CA 95124, (800) 538-5003 or (408) 559-1200; fax (408) 559-0250.
Circle 1282 on Inquiry Card.



The Super SX upgrade card is itself upgradable.

Run Mac Software on Your PC

A full-length PC card that lets your PC's 3½-inch floppy drive directly read and write to Macintosh floppy disks, AndOr One also lets you access your PC peripherals from Macintosh software. The card's AppleTalk-compatible RS-422 connector lets you network via LocalTalk and PhoneNet; its two SCSI ports let you connect other peripherals, such as SCSI hard drives and scanners.

AndOr One lets you switch back and forth between PC and Mac modes by simultaneously pressing both Shift keys on your PC's keyboard. The TSR AndOr software occupies about 60 KB of your PC's RAM. The card includes a licensed version of Word-for-Word/Mac, a utility that translates documents between PC and Macintosh formats.
Price: $995.
Contact: Hydra Systems, Inc., 1340 South Saratoga-Sunnyvale Rd., Suite 106, San Jose, CA 95129, (408) 253-5800; fax (408) 253-1113.
Circle 1283 on Inquiry Card.

Multiple-Drive IDE Interface

The IDE Controller from Boca Research supports two IDE hard drives and two floppy drives for ISA- and EISA-bus systems. The multiple hard and floppy drive interface fits into a single slot in any AT-compatible 16-bit-bus interface. The controller includes a 34-pin ribbon cable to connect a floppy drive and a 40-pin ribbon cable to connect an IDE hard drive. The controller provides an LED connection to monitor hard drive activity.
Price: $49.
Contact: Boca Research, Inc., 6413 Congress Ave., Boca Raton, FL 33487, (407) 997-6227; fax (407) 997-0918.
Circle 1284 on Inquiry Card.

Analyze Speech and Sound on Your Mac

Speech- and sound-analysis systems for Macs, SoundScope/16 and SoundScope/8 are designed for speech researchers and therapists, acoustical and audio engineers, and recording specialists. The systems let you use your Macs to record, play, edit, and view time waveforms and spectrograms; compute frequency spectra and linear predictive coding; add pertinent notes; and create custom displays.

SoundScope/16 turns your Mac II series computer into a CD-quality 16-bit stereo sound workstation via software, a plug-in NuBus card with a Motorola 56001 digital signal processor, Bose Apple Video Roommate-powered speakers, and a Shure microphone. The hardware digitizes stereo sound at 44.1 kHz (the sampling rate used to master CDs) with 16-bit resolution. The system accepts input from standard audio sources. You can customize SoundScope/16 without programming and store each custom configuration for later recall.

SoundScope/8, an 8-bit system for entry-level Macs such as the Mac Classic or Mac LC, digitizes sound at 22 kHz with 8-bit resolution from the included MacRecorder or the built-in microphone on newer Macs. Sound plays through the Mac's internal speaker.
Price: SoundScope/16, $4990; SoundScope/8, $1490.
Contact: GW Instruments, 35 Medford St., Somerville, MA 02143, (617) 625-4096; fax (617) 625-1322.
Circle 1285 on Inquiry Card.

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You're never out of touch with your own personal **"Windows on the World"!**

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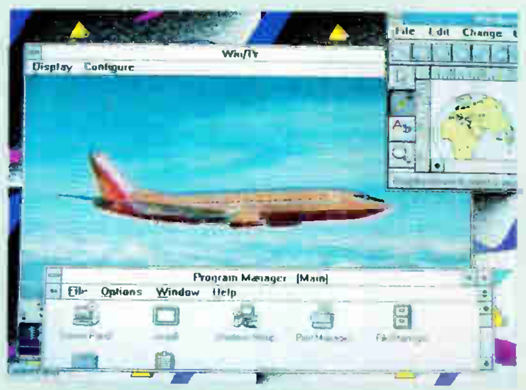

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First in a Family of Wireless LAN Adapters

Proxim's first wireless LAN adapter for desktop and portable computers uses spread-spectrum RF technology. The RangeLAN/ISA, a full-size ISA interface board, has an antenna that extends from the PC's backplane.

With a range of up to 800 feet, RangeLAN operates at a data rate of 242 Kbps. The board effectively triples the available bandwidth via its three full channels, letting you run three independent wireless LANS in the same physical space. The spread-spectrum technology provides a consistent data rate over the entire bandwidth, the company says.

Price: $495.

Contact: Proxim, Inc., 295 North Bernardo Ave., Mountain View, CA 94043, (415) 960-1630; fax (415) 964-5181.

Circle 1291 on Inquiry Card.

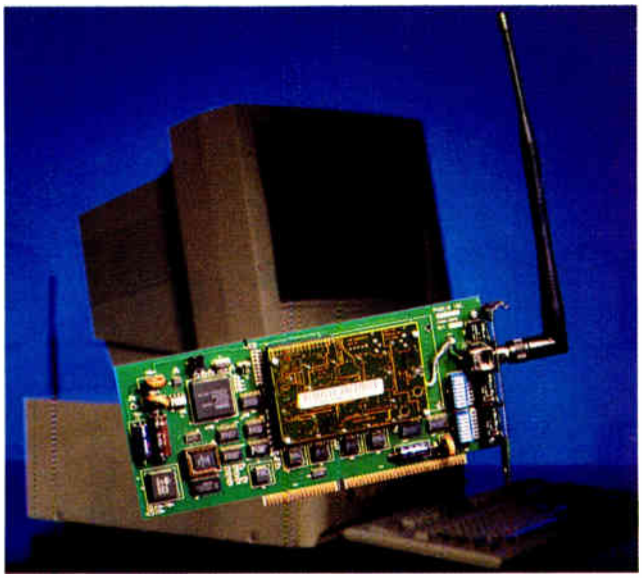
Cheaper by the Half-Dozen

A package of six EtherNic/8 10Base-2/10Base-5 network interface cards, EtherNic Six-Pack offers a savings over cards purchased individually. The EtherNic/8 card features high-speed-memory data transfer and a 32-KB RAM buffer. The card has a factory-installed jumper-selectable remote-boot PROM for compatibility with diskless LAN workstations.

Price: EtherNic Six-Pack, $995.

Contact: IMC Networks Corp., 16931 Milliken Ave., Irvine, CA 92714, (800) 624-1070 or (714) 724-1070; fax (714) 724-1020.

Circle 1292 on Inquiry Card.



A wireless LAN adapter, RangeLAN/ISA has an 800-foot range.

Integrated Office

Enable Office provides an integrated office system for networks. The modular four-user suite includes Higgins E-mail, calendaring, and scheduling, as well as Enable word processing, a 3-D linking spreadsheet, built-in Structured Query Language in a relational database, 3-D business graphics, and a communications module with scripting capabilities. The modules are integrated, so you can share data across applications.

Easy-to-use pull-down menus and full mouse support are part of Enable Office's simplified interface to Enable applications. You can open as many as eight windows at once on-screen and move data from one module to another. Each module can export and import data from stand-alone applications.

Price: Four-user office pack, $995.

Contact: Enable Software, 313 Ushers Rd., Ballston Lake, NY 12019, (518) 877-8600.

Circle 1293 on Inquiry Card.

Speak Through Windows on Your Network

InterActive M-Mail Systems lets you communicate in Windows on your NetWare network via voice. You can include text, pictures, and graphics as you like, combining the media by clicking on a mouse. Available in three versions, the multimedia system includes the company's InterActive M-Mail software, a sound adapter board for digitizing and playing back sound, and recording and listening devices for sound I/O.

Price: $295 to $395.

Contact: InterActive, Inc., 204 North Main St., Humboldt, SD 57035, (605) 363-5117; fax (605) 363-5102.

Circle 1294 on Inquiry Card.

Modem-Sharing on the LAN

Shared Access Modem Sharing Kits, available in single- and dual-port configurations, let you pool your modems on the LAN so that anyone can dial out. The kits also let remote users dial into the LAN.

The modem-sharing kits include V.32bis modems, cabling, communications and modem-sharing software, and a mouse-supported directory interface.

Price: Single port, $995; dual port, $1595.

Contact: USRobotics, Inc., 8100 North McCormick Blvd., Skokie, IL 60076, (800) 342-5877.

Circle 1295 on Inquiry Card.

Poste Gains Flexibility

Version 2.0 of Poste, Alfalfa Software's Unix-based E-mail system, adds a command-line interface, providing new capabilities for managing, sending, and receiving E-mail and faxes. Now you can access all of Poste's features from ASCII terminals, terminal-emulation packages, and the built-in X Window System GUI; create shell scripts to manipulate your mail; and define scripts for repetitive operations. You can configure your E-mail system, send or receive a fax from your computer, and dial into your E-mail from a remote location.

Price: Single-user copy, $395; 10-user license, $2950.

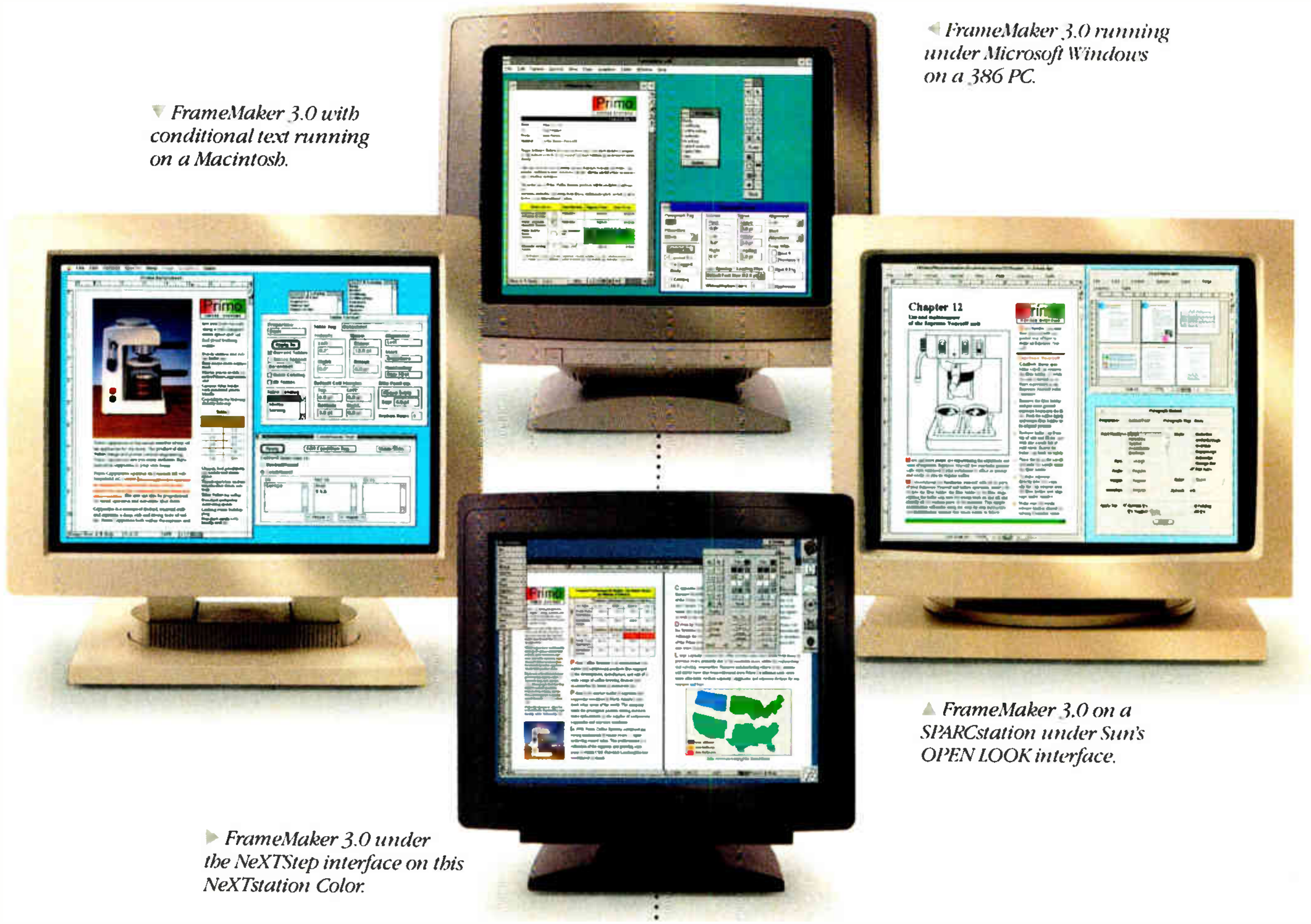
Contact: Alfalfa Software, Inc., 185 Alewife Brook Pkwy., Suite 4200, Cambridge, MA 02138, (617) 497-2922; fax (617) 876-2523.

Circle 1296 on Inquiry Card.

MULTI-PLATFORM DOCUMENT PUBLISHING

FrameMaker.

The richest blend in document publishing.



FrameMaker 3.0 with conditional text running on a Macintosh.

FrameMaker 3.0 running under Microsoft Windows on a 386 PC.

FrameMaker 3.0 on a SPARCstation under Sun's OPEN LOOK interface.

FrameMaker 3.0 under the NeXTStep interface on this NeXTstation Color.

Frame Technology® has a unique formula for publishing everything from simple memos to long, structured documents: FrameMaker®

FrameMaker blends into one integrated, easy-to-use program all the essentials of publishing: Authoring, editing, graphics, page layout, and production. Even math equations and hypertext.

And FrameMaker 3.0 blends in new robust and exclusive features. Like conditional text capabilities to help you generate and maintain multiple versions of a single document. And an integrated, multipage table editor.

FrameMaker is the perfect complement to all your hardware, because it runs on more platforms than any other publishing program. Including PCs running SCO Open Desktop or Microsoft Windows, Macintosh®, Apollo, DEC, HP, IBM, NeXT,™ Sun, and a host of other UNIX platforms—with complete file compatibility. So your workgroups not only share files, but also their skills and expertise.

For a taste of FrameMaker 3.0, call 1-800-U4 FRAME Ext. 961 for a ***free*** guide to integrating document publishing, and the name of your nearest reseller. And start brewing your own blend of publishing.

Frame™

Circle 42 on Inquiry Card.

Introducing Z▪NOTE.

The Z▪NOTE series starting at $2599. Call now 1-800-523-9393.

The future is built in.

Generations Ahead.

While the others are busy imitating the SL-notebook design we shipped last July, Zenith Data Systems is thinking two generations ahead. Our new Z▪NOTE brings a new genius to power management: *over four hours* of non-stop high-performance computing power. And our new "lid rest" feature allows you to close down without shutting down. It's simple, and it's just the beginning.

intel inside™

Notebooks Meet Networks.

The Z▪NOTE introduces notebooks to networking. *Built-in* networking. Believe it. We've put Ethernet on the motherboard. And we've pre-installed client shells for Microsoft® LAN Manager,™ Novell NetWare® and Banyan® VINES® Take your pick.

We've Seen The Future And It's In Color.

Our new active-matrix color display is a knockout. And the real beauty of it is that you can start with our high-contrast black-on-white model and upgrade to color in the future. In minutes. It's worth waiting for.

Who Needs A Docking Station?

Just snap on the optional, inexpensive READYDESK™ Port Replicator and you have instant access to all your office peripherals. It's pretty neat. It's Z▪NOTE.

Practice Makes Perfect.

There's no more-thoroughly-thought-out SL notebook on the market. Microsoft Windows™ 3.1 is pre-installed. The Logitech® TrackMan® Portable Mouse is included. LCD/CRT video is simultaneous. And the optional data/fax modem works worldwide. You won't get that kind of thinking from the rookies. It's called Thinking Ahead. And we're used to it.

MICROSOFT® WINDOWS™ READY-TO-RUN

Call 1-800-523-9393.

Reseller prices may vary. But call ahead. We'll tell you how we can guarantee prices on all four models. When you're Thinking Ahead, you think of everything.

320L	325L	325Lc
i386®SL-20 MHz	i386SL-25MHz	
60MB HDD	85 or 120MB	120MB
10.0" (9.5" v) VGA black-on-white display upgradeable to active-matrix color		8.4" VGA color
5.9 lbs.* *incl. nickel metal-hydride battery		6.5 lbs.*
4 hours continuous power, max 10 hours under Z▪NOTE *Premier System Management.*™ Expect about 1/3 less with color.		
ETHERNET NETWORK-READY Microsoft LAN Manager, Novell NetWare and Banyan VINES client shells		
WINDOWS-READY MS-DOS® 5.0 with APM/Microsoft *Windows* 3.1 Logitech TrackMan Portable Mouse		
UPGRADE OPTIONS Memory, BIOS, HDD, FDD, Co-Processor, Display		

320L *$2599*

325L *$3099* Model 85

325L *$3599* Model 120

325Lc *$5299*

ZENITH DATA SYSTEMS

A Bull Company

Thinking Ahead.

Circle 285 on Inquiry Card.

Resellers determine their own pricing which may be higher or lower than Zenith Data Systems advertised prices. All prices and specifications are subject to change. Prices are for models shown, in U.S. dollars. Shipping, handling, and applicable sales taxes not included in the price.

Dial In and Out on Your Network

The CAPcard, a self-contained network communication/application processor card, connects directly to the network without routers or bridges. CAPcard operates at full LAN speeds for file access and supports multiple protocols.

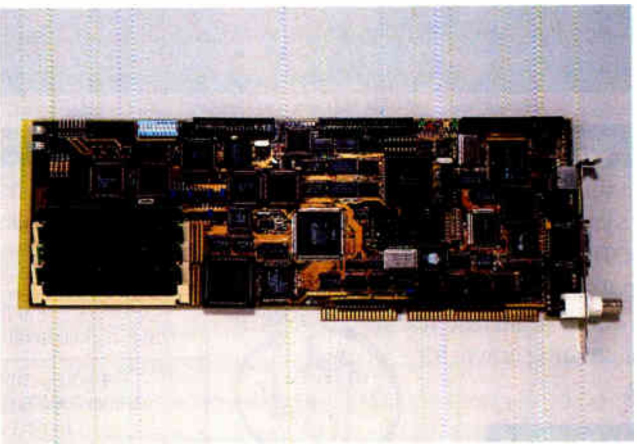
Compatible with DOS 5.0 and Windows 3.0, CAPcard provides dial-in/dial-out operation. CAPwatch, an on-board microcontroller, functions as a smart management processor, able to automatically reset the CPU. In dial-up use, CAPcard takes the telephone line off the hook when the card is unavailable for a dial-in call.

The card features a 25-MHz 386SX CPU, 2 to 16 MB of RAM, VGA, two high-speed serial ports, a parallel port, floppy drive and IDE drive interfaces, and an NE2000-compatible Ethernet controller with connections for 10Base-T and thin coaxial cable.

Price: With 2 MB of RAM, $1995.

Contact: Evergreen Systems, Inc., 120 Landing Court, Suite A, Novato, CA 94945, (415) 897-8888; fax (415) 897-6158.

Circle 1297 on Inquiry Card.



The CAPcard provides remote access to your network.

Three Ways to Fax

The NuCOM Force internal send-and-receive fax/data modem for NuBus-based Macs lets you receive faxes when your Mac is turned off. NuCOM Force automatically turns the computer on when the card detects the ring of a fax machine or modem and turns the computer off when the transmission is completed.

A V.17 14,400-bps fax/V.32bis 14,400-bps data modem, NuCOM Force includes V.32, V.42, V.42bis, and MNP level 5 capabilities. V.42bis lets you increase your transmission speed with NuCOM Force from 14,400 bps to 57,600 bps.

Price: $899.

Contact: PSI Integration, Inc., 851 East Hamilton Ave., Suite 200, Campbell, CA 95008, (800) 622-1722 or (408) 559-8544; fax (408) 559-8548.

Circle 1298 on Inquiry Card.

The Pocket BulletModem P9696MX is a 6½-ounce wallet-size portable modem that sends and receives faxes. The modem uses the extended Hayes AT command set and QuickLink fax software.

Able to operate on AC or battery power, the Pocket BulletModem P9696MX has 9600-bps Group 3, Class 2 fax capabilities. It is compatible with V.42bis at 38,400 bps; V.32bis at 14,400, 9600, and 4800 bps; V.22bis at 2400bps; V.22 and Bell 212A at 1200 bps; and Bell 103 at 0 to 300 bps. The unit also supports MNP levels 2 through 5.

Price: $745.

Contact: E-Tech Research, Inc., 3525 Ryder St., Santa Clara, CA 95051, (408) 730-1388; fax (408) 730-2488.

Circle 1299 on Inquiry Card.

A 9600-bps data modem that has 9600-bps fax capabilities is available in versions for the PC and the Mac. The external 9696XV for PCs and M9696XV for Macs support V.32, V.42, V.42bis, and MNP level 5 protocols. Using V.42bis, the units have throughput speeds that are as high as 38,400 bps.

The modems work lying flat, on end, or attached to the computer with Velcro. Other features include CMOS technology, self diagnostics, and automatic dialing and answering.

Price: 9696XV (for the PC), $549; M9696XV (for the Mac), $599.

Contact: Logicode Technology, Inc., 1817 DeHaviland Dr., Newbury Park, CA 91320, (805) 499-4443.

Circle 1300 on Inquiry Card.

NetWare to SCO Unix

TES for SCO lets you access SCO Unix from your NetWare LAN without having to convert to or add PC TCP/IP software to your system. The software provides terminal log-in capability via the native Novell IPX protocol. The basic components of TES for SCO are an SCO Unix server module, a standard TES client, and optional Windows support for NetWare PC users.

Price: Starts at $625.

Contact: InterConnections, Inc., 14711 Northeast 29th Place, Bellevue, WA 98007, (800) 950-5773 or (206) 881-5773; fax (206) 867-5022.

Circle 1301 on Inquiry Card.

Know Who's Calling

Whozz Calling uses your local phone company's Caller ID service to intercept the ID information before you answer your phone. The product sends the identification of the caller via standard RS-232 serial wire to your computer, which looks up the caller name, displays it, stores it, elects not to answer the call, or diverts the call to an answering machine. A DOS-compatible, menu-driven TSR program can optionally pop up information about the caller, bringing up the caller's ID before you answer the phone.

Price: $79 (requires Caller ID).

Contact: Zeus Phonstuff, 1000 Holcomb Woods Pkwy., Suite 410-C, Roswell, GA 30076, (404) 587-1541; fax (404) 587-1609.

Circle 1302 on Inquiry Card.

HEFTY HEFTY HEFTY

WIMPY WIMPY WIMPY

Want to play around? Get Corel Draw. But if your *work depends* on precision drawing, you should realize just how much more you can accomplish with Micrografx Designer.™

Important things. Like putting up to 64 layers in your drawings. "Snapping" objects to align them perfectly. And editing drawings on the full screen, in color, instead of a wimpy black-and-white box.

> **"Designer is the power user's choice."**
> *PC Magazine*
> *"Editor's Choice"*

Then there's Designer's poster-size 132″ by 132″ drawing area. Corel's is a mere 17″ by 17″ – leaving you to strip pieces together for larger drawings.

And don't forget clip art. Designer is packed with over 1,700 ready-made illustrations. Corel, only 750.

If you have questions about using Designer, you can turn to help screens *or* our 24-hour telephone support. But you won't find any help screens in Corel Draw. And don't bother to call them after hours.

Features	Designer	Corel Draw
Drawing layers	64	1
Dimensioning	Yes	No
Object snap	Yes	No
Maximum drawing size	132″ × 132″	17″ × 17″
Edit in full color	Yes	No
Clip art images	Over 1,700	750
Type 1 fonts	180	0
PageMaker 4.0 filter	Yes	No
On line help screens	Yes	No
24-hour support	Yes	No

> **The experts' verdict:**
> **"No contest."**
> *Software Digest* gave Designer five stars to Corel's three, concluding: ***"Designer provides the best overall free-form graphics package. It offers state-of-the-art features, good performance, and unmatched ease of learning and use in a sophisticated package."***

Why waste your time with a wimpy product when you can really flex your muscles with Designer? Call us today for a *free* working model, or for the location of the dealer nearest you.

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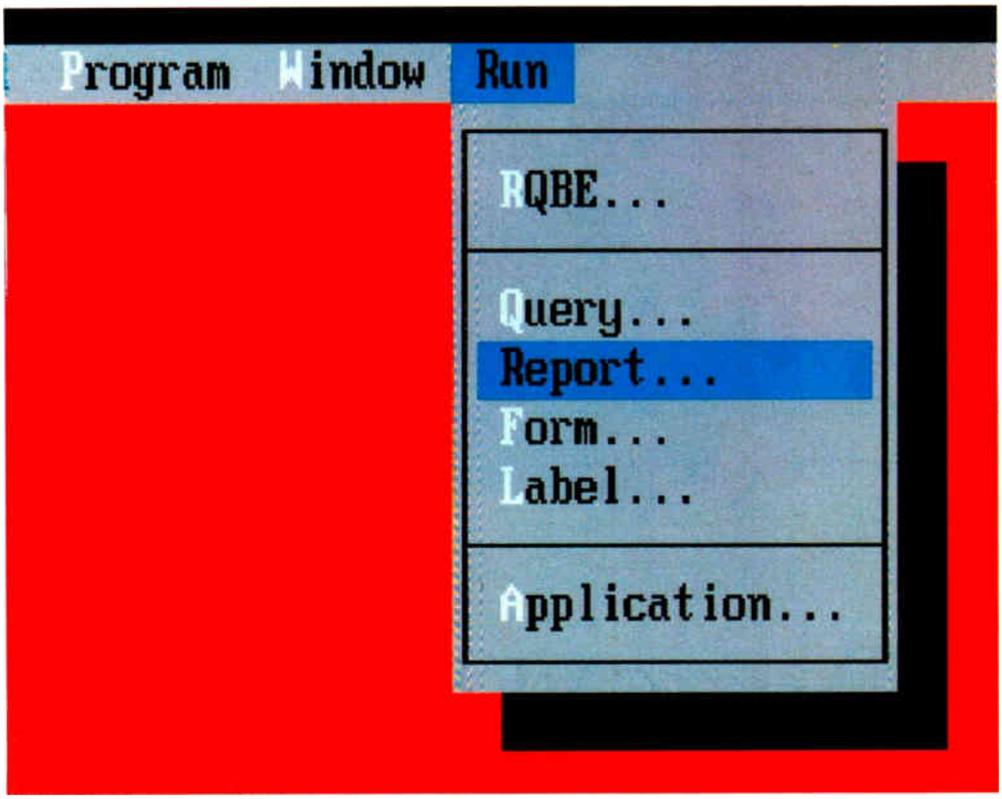
Micrografx, Inc. 1303 Arapaho, Richardson, TX 75081 (214) 234-1769. Micrografx has offices in Toronto, Paris, London, Munich, Milan, Copenhagen and Tokyo.
Designer system requirements: 286 (386 recommended) IBM PC or compatible, or PS/2. 1 MB RAM (2 MB RAM recommended). 20 MB (or larger) hard disk. Windows 3.0. DOS 3.1 (or higher). Mouse or digitizing pad. Windows-compatible monitor.

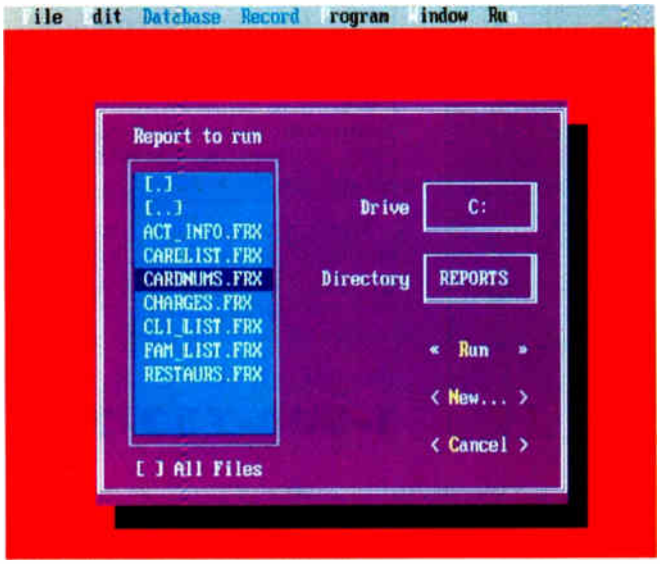
Circle 66 on Inquiry Card.

See Fox *RUN.*



We've just added a new word to the database vocabulary: *RUN.*

And it can make you a master of your database management universe. Even if you've never managed a database before.



The most powerful PC DBMS available is now the easiest to use, too: FoxPro™ 2.0.

Pick *Run* from the FoxPro 2.0 main menu and you have instant access to your information. Click on *Report*, choose the name of the report you want, and it's yours. Do the same for queries, forms, labels and applications.

For answers on-the-fly, pick *RQBE* (Relational Query By Example) and get a simple interface for creating custom queries quickly and easily. Unlike other query systems, RQBE lets you browse the information or create instant databases, reports, labels, or business graphs (with optional FoxGraph or other graphic program).

Custom systems are easy, too.

You create quick reports, forms, labels and applications by clicking on the *New* button in the dialog box instead of picking a name from the list.

Then using our simple tools, you build forms containing buttons, lists, check boxes, text regions and data fields. Reports with headers, footers and

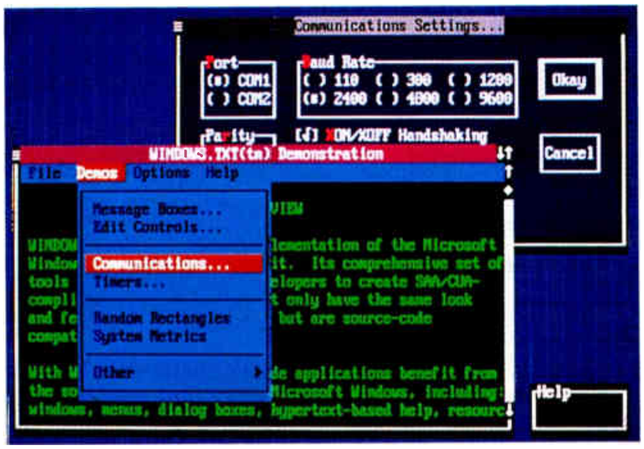
NEWS

Port Windows Applications to DOS

Windows.txt/DOS, the first member of Interactive's WinPort family of GUI cross-development tools, lets you develop DOS text-mode versions of your Windows applications. Based on the Windows application programming interface, the WinPort products provide equivalent libraries for native Windows API functions. As a result, you can port Windows applications to DOS and other environments.

Windows.txt/DOS comes with licensed Windows Software Development Kit components; C and C++ libraries for Microsoft, Borland, and Zortech compilers; and several references. Utilities also included with the program are a resource compiler, a compatibility checker, and a dual-monitor message viewer.

Price: $395; $695 with library source code.
Contact: Interactive Engineering Corp., P.O. Box 7022, Boulder, CO 80306, (303) 440-7674.
Circle 1303 on Inquiry Card.



Besides making your DOS applications Windows source code–compliant, Windows.txt/DOS provides true Windows look and feel across platforms.

Build Install Programs Scriptlessly

The Embark Professional toolkit offers a "scriptless" installation software generator for creating master disks and simplifying the distribution and updating of stand-alone and networked software. You can use the program's file compression and decompression capabilities, PXC welcome screens, display of README files, and AUTOEXEC.BAT/CONFIG.SYS modifications to build installation programs. Your installation programs can branch according to any combination of conditions on the end user's machine.

Other Embark Professional features include a disk-preparation simulation facility and an automatic master disk history file creator.

Price: $299.
Contact: Stingray Corp., 355 East Central St., Suite 204, Franklin, MA 02038, (508) 520-4562; fax (508) 520-4172.
Circle 1304 on Inquiry Card.

Embark Professional's File Selection window lets you define with a mouse-click the files you want on your master disk set.

Create Windows Apps with zApp

The zApp Windows applications framework encapsulates the entire Windows application programming interface into C++ objects for simpler creation of Windows applications and improved portability to other platforms. The object-oriented programming tool offers 120 classes of objects and is compatible with both the Zortech and Borland C++ compilers.

According to the developer, zApp features optimized memory allocation, hierarchical dynamic message handling, and complete compatibility with existing C-based Windows applications. zApp's print job subsystem provides automated support for banding, status dialog boxes, and other printing tasks.

Price: $195; $295 with source code.
Contact: Inmark Development Corp., 2065 Landings Dr., Mountain View, CA 94043, (415) 691-9000; fax (415) 691-9099.
Circle 1305 on Inquiry Card.

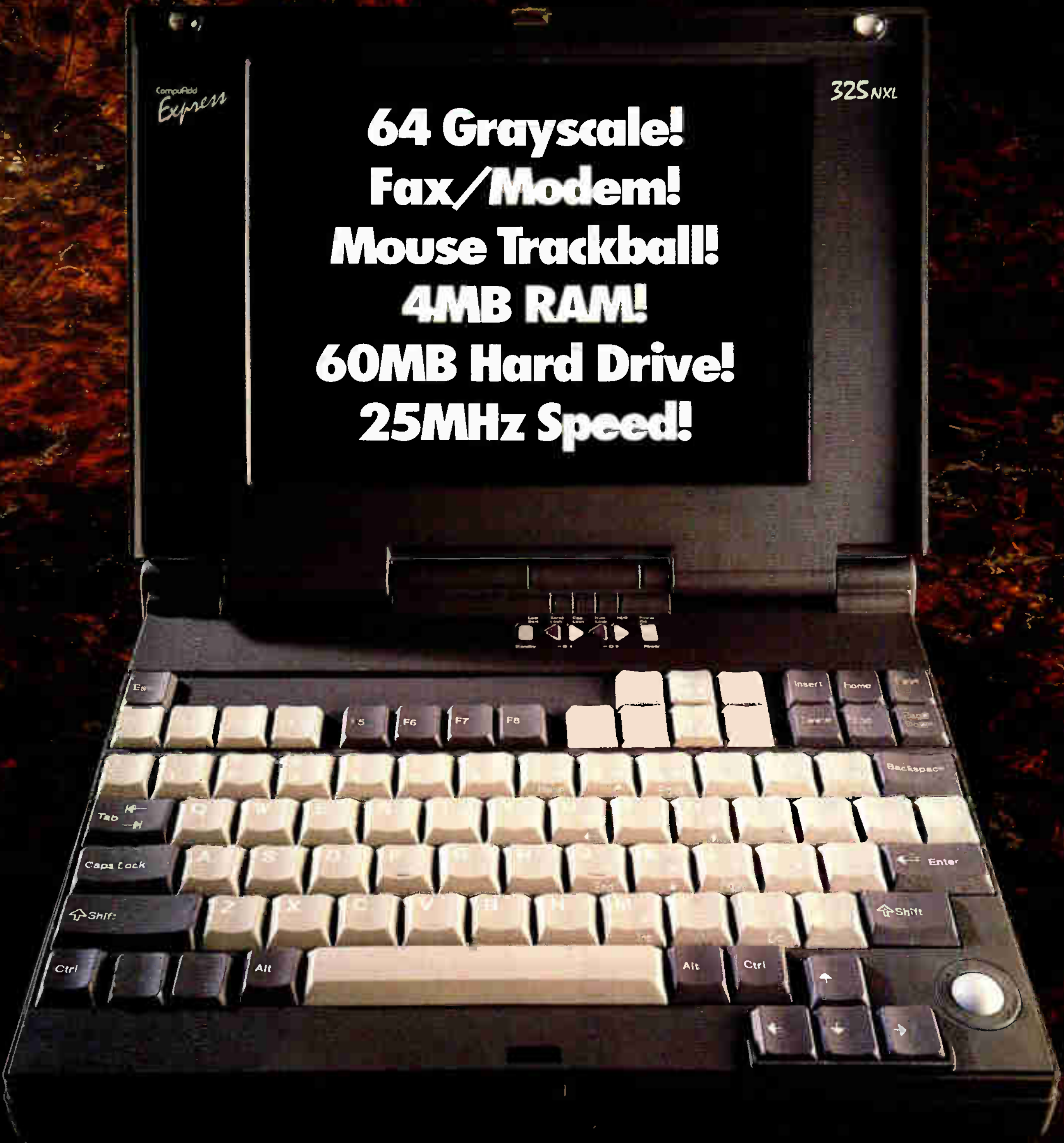
Serius OOP for the Mac

New versions of Serius's Programmer and Developer introduce ObjecTalk (syntax-free natural-language scripting) and Subjects (user-definable super objects) to object-oriented programming. Release 3.0 of Serius Programmer and Developer both provide a library of 48 objects and 350 programming functions to the Macintosh programmer.

Icons or user-definable ObjecTalk labels represent objects within Programmer 3.0. You can connect the representations graphically or through a simple natural-language script to build compiled stand-alone applications. Developer 3.0 builds on Programmer, letting you design custom objects using a lower-level development tool such as Think C or Think Pascal.

Included with both Programmer and Developer are libraries that provide tools for building all aspects of the Macintosh interface, as well as a set of objects for creating multiuser relational databases. The new Subject tool works like a macro; Subjects are user-definable groups of objects and functions that you can reuse in different applications.

Price: Serius Programmer 3.0, $395; Serius Developer 3.0, $595.
Contact: Serius Corp., 6400 Commerce Park, 488 East 6400 South, Suite 100, Salt Lake City, UT 84107, (800) 876-6847 or (801) 261-7900; fax (801) 261-7910.
Circle 1306 on Inquiry Card.



LOOK HOW MUCH WE SQUEEZED INTO OUR NEW NOTEBOOK . . .

...WITHOUT PUTTING THE SQUEEZE

You and your budget both will feel comfortable with the Express 325NXL. With features like a built-in trackball and fax/modem, 4MB of RAM, 25MHz of 386SX speed and the amazing, utility-filled DR DOS 6.0, you won't be making any sacrifices for portability's sake. This notebook can handle work you entrust to your office system. But at *ONLY $2,095* **the Express 325NXL easily fits among low priced notebook computers on the market today.**

The 325NXL has the lightweight portability that every notebook promises. But even with all these features, it weighs less than 6 pounds — including battery — and measures only 8.5" x 11". The 325NXL fits comfortably into your briefcase, but just in case you want to pack it separately, we give you a free carrying case.

Look at our video display. It's sharper than other notebooks'. ✔ A big 9.4" screen, measured diagonally ✔ With 64 levels of grayscale for a bigger, clearer image than notebooks with only 16 or 32 levels. ✔ .30mm dot pitch. ✔ A super-twist backlit liquid crystal display. ✔ And in the office, hook up to a VGA monitor using the 325NXL's external VGA video connector.

When you run Windows on the road, this is the notebook to use. ✔ Our 60MB hard drive and 4MB of RAM mean big Windows programs will run just fine. ✔ Use the DR DOS 6.0 data compression feature and your drive can hold up to 120MB! ✔ Transfer data easily with a 3.5" internal floppy drive.

3.5" internal floppy

Why carry a clip-on trackball? The 325NXL has one built-in so you'll always have a trackball when Windows applications require it. ✔ 200 dots per inch resolution for accurate pointing. ✔ Two click buttons select icons and commands. ✔ When you're in the office, connect a mouse using the 325NXL's external PS/2 mouse connector.

Add a coprocessor

You won't have to wait until you're in your office to get to work. And you won't have to wait for your data while you're using your 325NXL. ✔ Our 25MHz Am386SXL microprocessor is faster than most notebooks', which typically run at only 16MHz or 20MHz. ✔ Add a math coprocessor, and applications that use floating point instructions will run even faster. ✔ Order a coprocessor with your notebook and we'll install it for you.

Communication is so important on the road, you shouldn't have to pay extra to add it. ✔ So the 325NXL has a built-in 9600 baud fax / 2400 baud modem. ✔ And Quick Link II fax/modem software is included free. ✔ The 325NXL has one RS- 232 serial port and one parallel printer port so you can connect to printers and other peripherals in the office.

You'll feel right at home on our keyboard. ✔ It has the familiar feel of an IBM because it's made by the same manufacturer. ✔ The standard 101-key function keyboard is implemented with 84-key layout. ✔ And the inverted "T" arrow keys are just like your standard keyboard's — set apart in the lower right hand corner so they're easy to find. ✔ You also can connect to a standard PS/2 keyboard with our external keyboard connector.

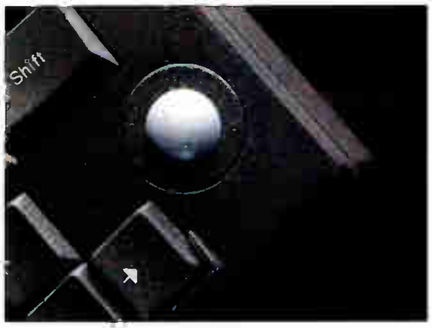
Inverted "T" arrow keys

You won't be stranded without power to work. ✔ The 325NXL's built-in power management logic gives you up to 4 hours of battery life. ✔ Close the lid, and a sleep button saves power by shutting down the display and drives but preserving your data in RAM. ✔ Our AC adapter is compact and easy to take with you.

Ordering's a breeze, too. Just call us toll free at *800-925-3525*

ON YOU

Free carrying case



Built-in trackball

1 serial, 1 parallel port: fax/modem, keyboard, mouse, VGA monitor connections.

Power, display control, sleep buttons on keyboard

We accept MasterCard, VISA, money orders, certified checks (please allow ten days for processing), CODs ($50 deposit required), company and institutional purchase orders (minimum initial purchase $250, thereafter $50 with approved credit) and wire transfers. Shipping charges are calculated according to weight and distance. Texas residents, please add appropriate local sales tax. CompuAdd Express will replace or repair defective hardware, software and consumable items. A 15 percent restocking fee may be charged. All return items must be accompanied by a return merchandise authorization (RMA) number. Prices and product descriptions are subject to change without notice. CompuAdd Express is not liable for damage due to omissions or typographical errors.

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Express 433

$2,195

120MB AND HRVGA

Putting the features you want into the full profile Express 433 wasn't as tight a fit as our notebook. But we kept one thing small — the price tag.

Here's a terrific reason to step up to full 486 computing. The Express 433. This 33MHz system has speed and power features like a built-in math coprocessor and built-in cache that come with every 486. PLUS Express enhancements. PLUS low price. At only $2,195 for a 33MHz 486 with 120MB hard drive and Hi-Rez VGA monitor, the 433 is ready to take you into computing's future.

You'll have the speed you want. Because we've added another 64KB cache on the motherboard for a zero wait state memory access. You'll have the controllability you want. Because like all Express systems, the 433 comes preloaded with DR DOS 6.0, the operating system that includes a data compression feature that can give you up to double the normal capacity on your hard drive. And you'll have the expandability you want. Because you get our standard dual floppy drive that frees two bays for extra hard drives, a tape backup or CD ROM. And because you get eight expansion slots in this full profile box.

Systems for Every Need

The 433 is our most powerful system. But for computer users with less demanding needs, we offer a full line of 486SX, 386, 386SX and 286 systems. All with Express enhancements like our dual floppy drive and DR DOS 6.0. And all with amazingly low prices!

420s - $1,895
486SX/20MHz; 80MB HD; HRVGA

333 - $1,795
386/33MHz; 80MB HD; HRVGA

325s - $1,295
386SX/25MHz; 40MB HD; HRVGA

216 - $1,095
286/16MHz; 40MB HD; HRVGA

CompuAdd Express

Call to order, for other system configurations or for a free catalog:

800-925-3525

512-219-1800 Fax 512-219-2890

Hours: 8AM-6PM Mon-Fri CST 12306 Technology Boulevard, Austin, Texas 78727

Paperless Office Means Business

Norick's Paperless Office truly lives up to its name. The PC-based package combines tools for document imaging; sending/receiving faxes; E-mail; on-line memo pads; and document searches, viewing, and manipulation. You can also import documents from most popular spreadsheets, word processors, and CAD programs, including those from Lotus, Borland, Microsoft, and WordPerfect.

The program assigns each document several cross-reference flags; system date, origin date, document ID number, and document description are the indicators the program uses to search for documents. You can also attach file cabinet descriptions to each document.

Norick's Paperless Office runs under your existing PC environment (e.g., DOS, Windows, or Desqview).

Price: $249; $495 for five-user network version.

Contact: Norick Software, Inc., 5400 Northwest Grand Blvd., Suite 450, Oklahoma City, OK 73112, (800) 527-5764 or (405) 947-7560; fax (405) 946-7559.

Circle 1307 on Inquiry Card.

The file cabinet feature of Norick's Paperless Office lets you build file folders containing contact information, notes, and other information and link folders to specific documents. Here the "public relations" folder of the "advertising" file drawer is open. The file cabinet belongs to Judy.

Graphing Spreadsheets on the Mac

PowerPlay for Macintosh lets you access data from spreadsheets or databases and display it graphically. By using the program's "drill down" feature, you can get the details behind certain figures. For further insight, PowerPlay lets you manipulate your source data and switch among time, revenue, sales, and inventory dimensions.

In addition to supporting Mac-based data sources, the program lets you extract and display information from Structured Query Language sources. PowerPlay is System 7.0–savvy and supports File Sharing, Publish/Subscribe, Balloon Help, and the Data Access Manager.

Price: $695.

Contact: Cognos, Inc., 67 South Bedford St., Burlington, MA 01803, (617) 229-6600; fax (617) 229-9828.

Circle 1308 on Inquiry Card.

PowerPlay gives you a graphical representation—in this instance, a pie chart—of your spreadsheet or database information.

AttiTools: Four Products in One

AttiTools offers Windows users four means by which to organize their local and networked data files. The collection of utilities consists of Catalyst, a graphical disk directory manager; SlingShot, a file launcher; DiskSpace, hard disk space utilization and analysis software; and Dragnet 3.0 software, for full-text search and retrieval. Also available as a stand-alone product, Dragnet 3.0 lets you do sequential keyword searches over multiple drives for files whose names you don't know.

Price: $129.95; Dragnet 3.0 only, $99.95.

Contact: Attitash Software, Inc., 20 Trafalgar Sq., Nashua, NH 03063, (603) 882-4809; fax (603) 882-4936.

Circle 1309 on Inquiry Card.

Turn Spreadsheets into Databases

The R&R Report Writer lets users of Lotus 1-2-3, Symphony, and Borland's Quattro Pro treat their spreadsheet files as database information. Report Writer lets you select, sort, analyze, and present data without changing the original spreadsheet.

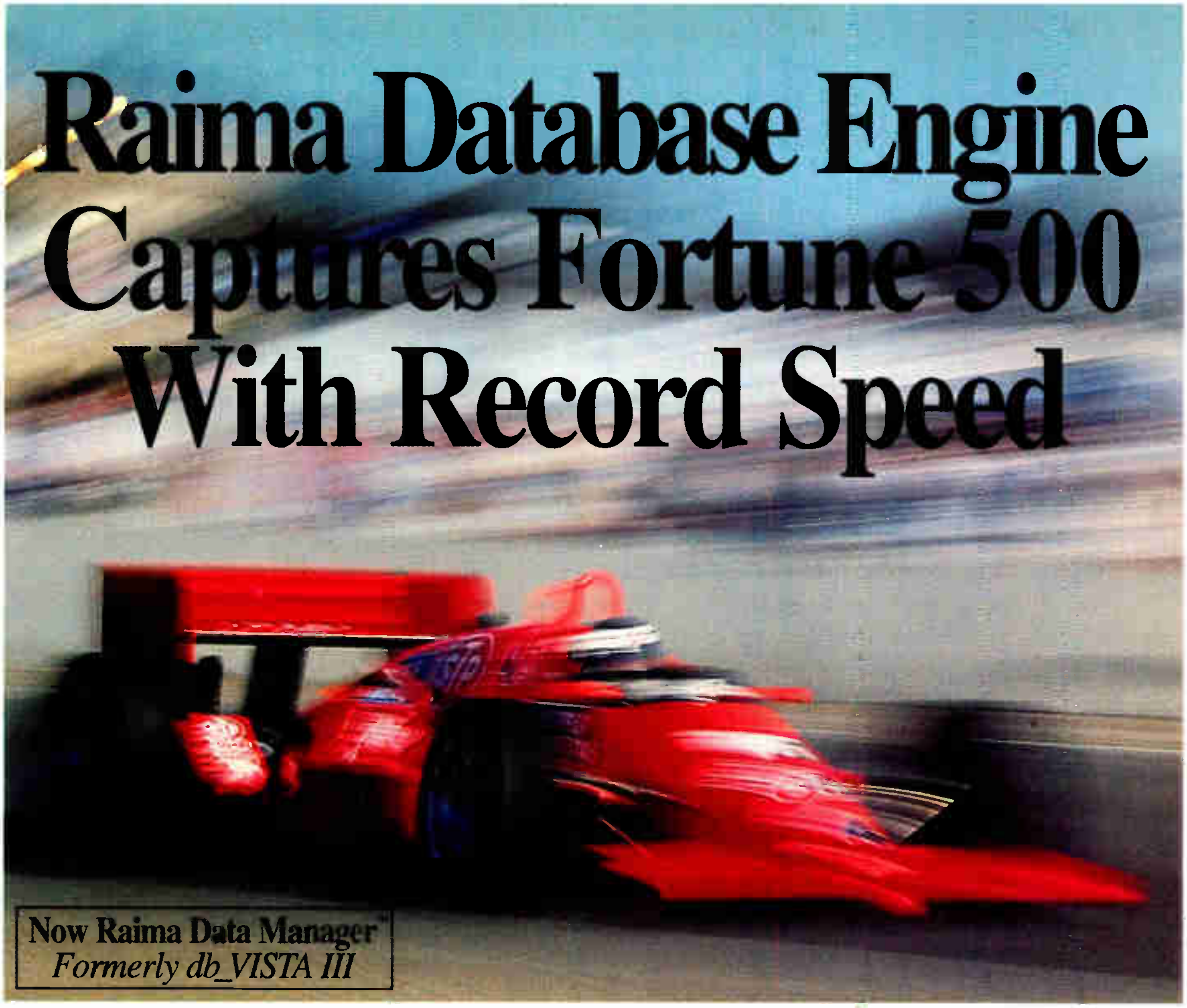
Version 4.0 of the program provides proportional font support for a variety of printers, including PostScript devices. The improved font support lets you work with cartridge-based, downloadable, and internal standard and scalable fonts.

Other new features of R&R Report Writer 4.0 include 75 functions for spreadsheet string, date, and numeric manipulation. The program lets you sort and group records in any order, and you can specify complex relationships and record selections in plain English.

Price: $249.

Contact: Concentric Data Systems, Inc., 110 Turnpike Rd., Westborough, MA 01581; (800) 325-9035 or (508) 366-1122; fax (508) 366-2954.

Circle 1310 on Inquiry Card.



Accelerated Database Performance

Compared to conventional relational databases, retrieval of records can be 10—20—even 50 times faster with Raima Data Manager from Raima Corporation.

Propelling The Biggest Names In Business

Companies like General Motors, Hewlett-Packard, IBM, Eastman Kodak, Rockwell and others are using Raima Data Manager in their competitive environments. Today's most critical, most demanding applications demand the high performance of Raima Data Manager.

Powerfully Efficient Leading-Edge Technology

Raima's combined technology merges the flexibility of relational databases with the lightning speed and efficient storage of the network model. With the program written entirely in C, you can "fine-tune" the Raima Data Manager engine for optimum performance in any application.

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An add-on to National Instruments' LabView data acquisition program, Beam Analysis Vi is a laser beam analysis, diagnostic, and characterization tool. BAV lets you perform beam calibration, intensity profiling, and calculation of beam measurements.

Based on an image-processing library for LabView called Image Concept Vi, BAV is a library of LabView virtual instruments. You can measure characteristics such as beam area, peak intensity, location of beam centroid, and roundness factor. The system provides continuous measurement updates within a report window and plots beam intensity profiles.

Price: $500; $1700 with Image Concept Vi.
Contact: GTFS, Inc., 2455 Bennett Valley Rd., Suite 100C, Santa Rosa, CA 95404, (707) 579-1733; fax (707) 578-3195.
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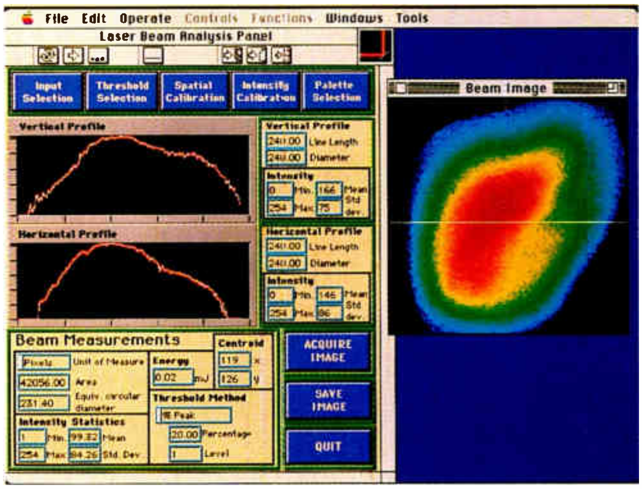

Beam Analysis Vi monitors multiple laser beam characteristics simultaneously.

Graph Nonstandard Data onto a Grid

With PV-Wave:GTGrid (PVGT) you can transform large, nonuniform data sets into precise surfaces and contours and display that data graphically. Its developer reports that PVGT will graph 10,000 irregularly located data points into a 40 by 40 grid in 30 seconds on a Sparcstation 1. The PVGT grids can include faulting information, which lets you account for natural boundaries and barriers.

PVGT, an add-on to the PV-Wave command language, is the result of a technology merger between Precision Visuals' PV-Wave and Geophysical Techniques' Surfas. Like PV-Wave, it lets you import coordinate data via most Unix-based file formats.

Besides using the program to graph physical data points, you can use PVGT to display multivariant financial data. The program runs on a variety of Unix workstations, including those by Sun, DEC, IBM, Hewlett-Packard, and Silicon Graphics.

Price: $895 for a single floating license.
Contact: Precision Visuals, Inc., 6230 Lookout Rd., Boulder, CO 80301, (303) 530-9000; fax (303) 530-9329.
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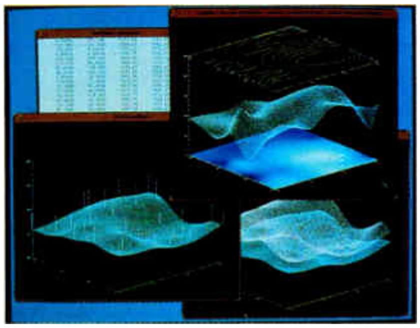

PV-Wave:GTGrid uses well-location data with water-level information (upper left window) to create continuous mesh surface plots of the underground water table.

Translate Data Points to x, y Coordinates

UnGraph does the reverse of what most graphing applications do: It vectorizes scanned graphs and provides the *x*, *y* coordinates of the graphed data points. The program works with graphs that present data in a line (i.e., in *x*, *y* format).

UnGraph provides a controller for Logitech's ScanMan and also accepts TIFF and PCX line art from other sources. You can use the program's paint tool to fill in any gaps in your line chart. Once the program has read and translated graphed points to coordinates, you can export the coordinate information to other applications as ASCII or DXF files.

Price: $399.
Contact: Biosoft, P.O. Box 10938, Ferguson, MO 63135, (314) 524-8029; fax (314) 524-8129.
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FORTRAN Math and Statistical Programming

The IMSL FORTRAN Libraries for the Next contain more than 900 subroutines for developing mathematical and statistical applications. The subroutines incorporate basic linear algebraic subroutines and automatically calculate and allocate workspace.

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The libraries are callable from both FORTRAN and C and require the use of Absoft FORTRAN 77 for the Next.

Price: $2000.
Contact: Absoft Corp., 2781 Bond St., Rochester Hills, MI 48309, (313) 853-0050; fax (313) 853-0108.
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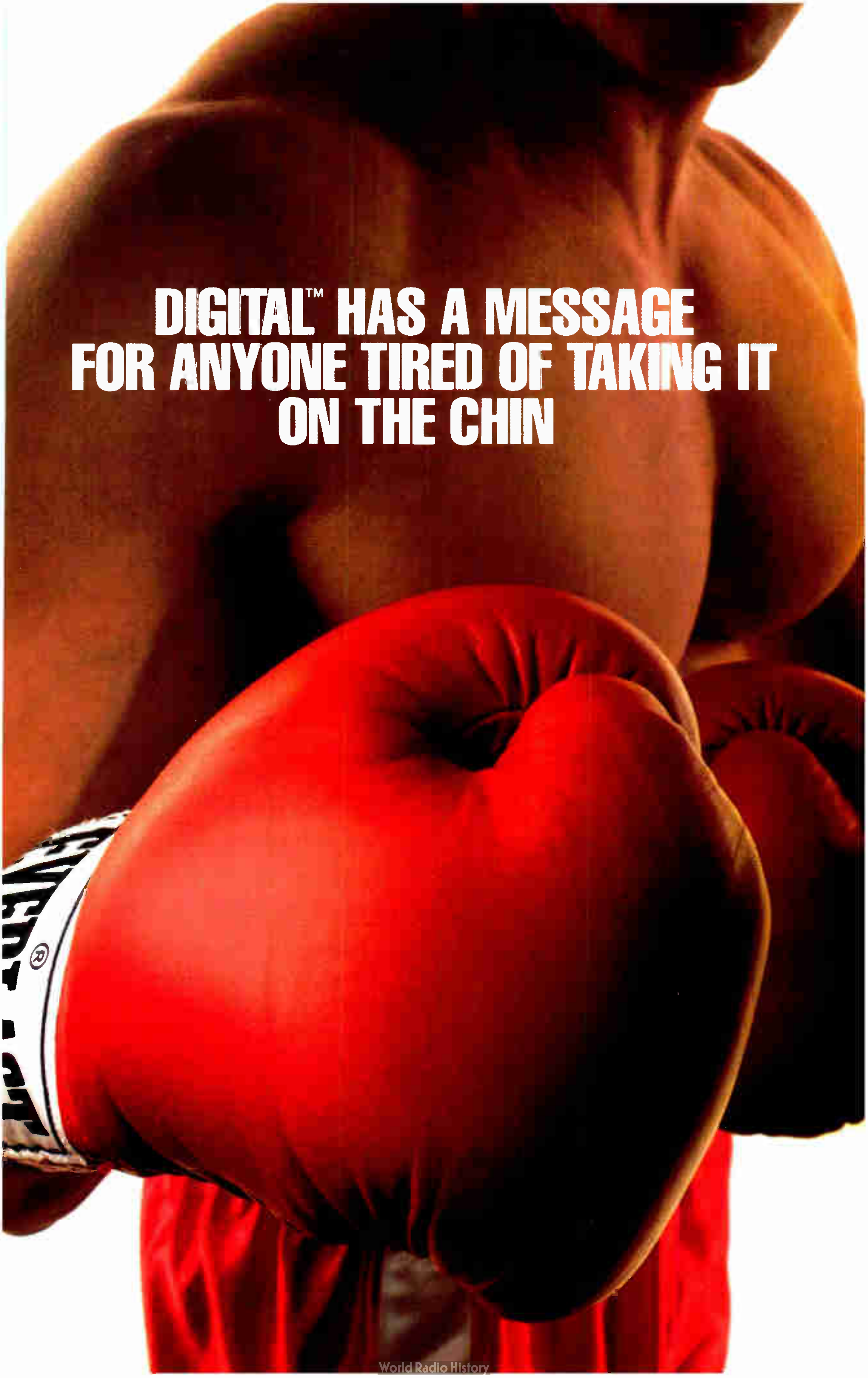
ERRATA NOTICE

Desktop Direct from Digital regrets that an inaccurate photograph accompanies their 420sx configuration. Package No. DJ-PC445-09 in their ad appearing on page 84G. The copy for that configuration is accurate.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- ☐ The DECpc 320P Notebook
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Customization Worksheet

Your base system is a ☐ 286 ☐ 386 ☐ 486 ☐ Other

How many applications will your PC(s) run in a typical workday? ____

What best describes the type of work the system will be used for? (Check all that apply)

- ☐ Word Processing ☐ Desktop Publishing ☐ Scientific Research
- ☐ Order-entry ☐ Education ☐ Software Development
- ☐ Database (filing records) ☐ Design (CAD CAM) ☐ E-Mail
- ☐ Financial Calculations ☐ Engineering ☐ Other industry-specific applications (please specify)
- ☐ Retail Store Management ☐ Industrial Process Control

How many people work in your group, department or small business?
☐ Less than 10 ☐ 10-20 ☐ 20-35 ☐ More

Is your operating system
☐ DOS ☐ DOS with Windows ☐ OS/2 ☐ MAC ☐ UNIX™ ☐ Other

Which of the following graphics-oriented applications best describes your needs? (Check all that apply)

- ☐ Desktop Publishing ☐ Realtime Modeling ☐ AutoCad
- ☐ CAD CAM ☐ Animation ☐ Business Graphics
- ☐ Image Processing

LAN Communication

How many PCs do you have installed? ____ From how many manufacturers? ____

What kinds of connections does your PC(s) require? (Check all that apply)

- ☐ Links with other PCs in the immediate surroundings
- ☐ Connection to the local area network (LAN) throughout a building
- ☐ A line to a host system in a remote location

What kind of media (cable) is used in your LANs today? ____

What is the networking software now being used in your company? ____

What kind of host system will your PC communicate with?
☐ DECpc ☐ IBM ☐ Other ____

What Kind of Service Do You Really Need?

☐ On-site Hardware Support ☐ Software Support ☐ Telephone Support
☐ Training ☐ FAX Hotline

How many of your users take portables on the road? ____

Do you currently have a service contract(s) for your PCs? How many? ____

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Mouse:	Three-button
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Display:	20" Color Monitor
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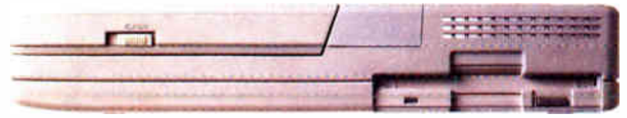

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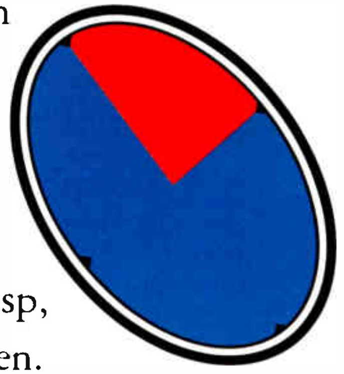

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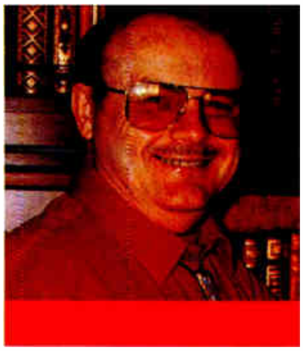


JERRY POURNELLE

UNSOLVED MYSTERIES

Triumph. Sing the paean. Windows 3.1 is stable and working at Chaos Manor, and I just love it. It hasn't been easy. This is a tale of victory through persistence. *Ad astra per aspera.* It has also been instructive. I'll start with the basics.

Windows vs. OS/2 vs. Desqview

Most of us can live without multitasking. Usually, the only thing that I let run in the background is communications, such as my programs to automate GEnie and MCI Mail. The programs log on, upload previous replies, grab everything I'm interested in, and log off, letting me read and answer mail and conference messages off-line before letting the programs have another round in the background while I do something else.

Otherwise, though, I don't particularly need multitasking: what I do need is task switching, the ability to quickly and painlessly go from one program to another, as from word processor to notebook to card file to telephone book to calendar to calculator. That sort of thing.

Desqview does that well, so I wasn't particularly intrigued by the first releases of Windows. I was even less interested in the first version of OS/2. Neither Windows nor OS/2 had any killer applications I just had to have. Windows 2.0 wasn't as good at DOS task switching as Desqview was, and OS/2 was worse. It needed a major hardware upgrade, and you could run only one DOS program at a time in the silly compatibility box. I often wonder if OS/2 was designed to fail. It sure looked like it.

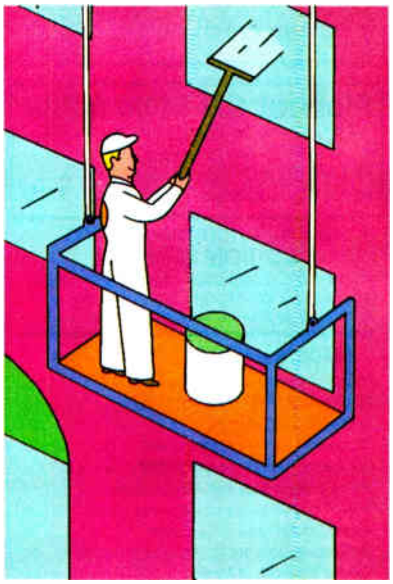
Then came Windows 3.0, and it looked pretty good. I liked the ability to do Alt-Return and collapse your DOS program into a small box. I liked the cut-and-paste features. Indeed, I liked almost everything about it, except for its tendency to suddenly flash the unhelpful message "Unrecoverable Applications Error" and die, taking everything else down with it. Windows users developed a special name for this: Windows would "UAE on you." (That's pronounced "YOU-eee.")

In version 3.1 that was fixed. Meanwhile, there appeared a score of really neat Windows-specific application programs. For a while, I made do by running Windows under Desqview. That works, but it was not much fun.

For one thing, many of Windows' best features are crippled unless you're running in enhanced (386) mode. I suppose this is worth explaining.

Windows has three modes of operation: enhanced, standard, and real. Enhanced mode can run only on systems with a 386 CPU. Standard mode will run on systems with a 286; it uses a screwy kludge to force the 286 to shift from protected mode to real mode. Standard mode lets you get at extended memory, and if you have enough memory, you can do task switching. If you run Windows 3.0 under Desqview, you get standard mode. Real mode forces your machine to believe it's only an 8086 and isn't interesting.

Windows problems that weren't, and the annual Orchid and Onion Awards finale



I figured that if I couldn't run Windows 3.0 in enhanced mode, it wasn't worth the bother. It was better to run Windows under Desqview. I got better results. Alas, running Windows under Desqview meant putting up with the quirks of two different environments. It felt like a kludge. It *was* a kludge. There had to be a better way.

IBM said a better way was to run Windows programs under OS/2 2.0, which they swore would be a better DOS than DOS and a better Windows than Windows. It would have all the neat features—there really are some—of OS/2 as well. Having told me all that at my panel at Fall Comdex, the IBM people promptly forgot who I was and never sent me a copy.

I thought it was time to choose, Windows or Desqview, and given that I didn't have OS/2, while I had a growing collection of great Windows programs, it was clear to me what the choice ought to be. There was only one problem: I could not make Windows work properly.

Interactions

It may be different now, but when I was in graduate school, psychologists never really learned statistics. What they got were cookbook formulas they would blindly apply to any heap of data they could generate. This was before computers, so some poor drudge would spend weeks punching numbers into a Monroe calculator to generate an analysis of variance. When it was all done,

ILLUSTRATION: STEVE TURK © 1992

you would generally hear the proud announcement that "all the interactions were significant."

No one quite knew what that meant, but it sure sounded profound.

I had much the same experience with Windows. The one problem with state-of-the-art equipment is that when something doesn't work, you can't be quite certain what precisely went wrong. It looked as if all my interactions were significant.

My first experiences with the beta copies of Windows 3.1 convinced me to wait for the final release copy. Until then, I made do with version 3.00a, which really meant I used Desqview for nearly everything and sometimes ran some Windows applications. The thing was, I found I missed the Windows environment. It really is fun, and there are a lot of conveniences.

When the final release of Windows 3.1 came, I installed it on my Cheetah 486/33. From experience, I have found that the Cheetah runs fast and clean. If something will work on any machine, it should work on a Cheetah. Besides, I had Windows 3.00a running on the Cheetah 486/25, which is identical to the 486/33 except for the faster chip and clock. It has the same Award BIOS and the same Perceptive Solutions HyperStore 1600 hard drive controller. Even the same Sound Blaster sound and game card. The only real differences were the monitors. The 486/25 has the big Hitachi high-performance monitor; the 486/33 had an old Zenith 31.5-kHz Flat Technology Monitor (FTM).

At first, all was well. The installation was simple. Everything worked, and it was fun like the old days with these little machines. Indeed, I got excited. I installed Ascend, the Franklin Time Management System, and loved it. I had no trouble getting my communications programs running in the background better under Windows than they ever had under Desqview.

I wasn't much thrilled with the various word processors for Windows. I didn't care for black on white, and most of the fonts looked ugly. Of course, I hadn't really investigated them; there would be time for that when Windows was stable. Besides, it didn't matter: Q&A Write, complete with Word Finder and the Definitions Plus American Heritage Dictionary, ran just fine, and I like it enough that I'm in no hurry to change.

Q&A also caused the first glitch.

To Share or Not to Share

When you install Windows, the program automatically stuffs SHARE.EXE into your start-up file, so it's natural to think you should be running it. If you do, though, you'll convince your system you're running a network. That's all right until you try to open a second copy of Q&A Write. It doesn't have multiple window capability; if you want multiple editing sessions, open several copies of the program. I've been doing that with Q&A and Q&A Write for years. Alas, when I tried it with Windows, the program informed me that I'd need a network version because no multiple copies were allowed.

At first I thought this was some bizarre copy-protection scheme, but it isn't. Symantec had been genuinely concerned about file clashes. Still, I could open multiple copies of Q&A Write under Desqview, but not under Windows.

It turns out, though, that what Q&A Write was detecting was triggered by SHARE.EXE. If I don't run SHARE, Windows will let me open as many copies as I've patience for. I discussed this with Microsoft technical-support people and found that I don't need SHARE at all—nor will most users. It's a relic. You don't need SHARE unless your system says you do, and maybe not then. Scratch one non-problem. Alas, it wasn't the last one.

Hurrah for Palindrome

Palindrome's Network Archivist isn't a Windows program. It will run under Windows, but I found out the hard way that you must not run it in the background. Of course, it makes sense not to run something as complicated as NA in the background. It checks all files and saves new ones onto the digital audiotape (DAT)—NA considers files identical only if they have the same name, size, time, and date—so if you make it share with anything that accesses disk files, there's a good chance the program will become confused.

Anyway, I ran NA under a DOS prompt that I submerged to the background. When NA was finished, it gave me some very strange messages. It didn't take long to find out that things were mucked up. NA didn't run properly and had to be restored.

Not being a complete sucker, I had run NA from non-Windowed DOS not long before trying it under Windows, so it turned out I lost nothing but some time. I used NA to restore itself and, just for the heck of it, the entire C drive. It worked splendidly.

The lesson is, don't run NA under Windows. But if you do, use the program information file editor to make a start-up PIF that assigns NA 100 percent of the system. NA is usually run automatically through a network, anyway. In my case, I find it no great hardship to exit Windows entirely before running NA. A few minutes ago I did that, set NA running, and

Why do they call it a dongle?

He wasn't famous. He didn't drive a fancy car, but dressed in his favorite Comdex T-shirt and faded blue jeans, he set out to change the course of the computer software industry. Quite a task for a lonely software developer.

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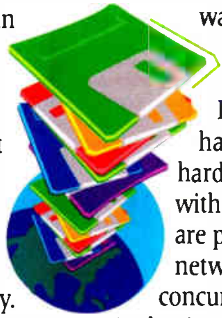
The Global Marketplace

From Paris to Prague, his program was everywhere in Europe. When he got off the plane in Hong Kong he found his program stacked to the ceiling in every computer store. Amazed in disbelief, he bought a hundred cartons of cigarettes and a hundred pounds of Indonesian coffee and flew back to Boston.

Beaten, battered and bruised he went back to the drawing board. This time he would really change the face of the software industry. He would develop a device that would prevent unauthorized distribution of software programs.



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Circle 94 on Inquiry Card (RESELLERS: 95).

went downstairs for coffee. It was done looking at and archiving some 900 MB of files by the time I got back.

Before entering Windows again, I ran Golden Bow's Vopt disk optimizer program. That's another one I don't recommend running when you're in Windows or Desqview. Anything that mucks about with your file allocation tables ought to be left to operate in peace...

Anyway, I remain partial to WORM drives, but I will now concede that if you have NA with a DAT drive, you don't need a WORM drive. Palindrome gets a User's Choice Award for NA; it's all you'll ever need for backups.

WORMs and Tapes

However, WORM drives remain pretty valuable. Last month, just before I got sick, I got an official notice from the Internal Revenue Service. They'd compared the forms that various outfits like McGraw-Hill and my overseas sales agent Ralph Vincenanza send in, showing what they paid out to my own tax returns, and thought there might be a discrepancy. The IRS is really sticky about unreported income.

I'd actually reported it all. Ralph's, for instance, was lumped into Ledger Page 401, "Agented Income"; so all I had to do was show a copy of that page and its totals, and they'd see that it added up to what Ralph had reported. The only problem was that this was for 1989, and I had long since archived all that stuff. Worse, it was stored on old Maximum Storage WORM cartridges that had been created by an obsolete WORM drive.

It turned out to be another nonproblem. I don't have the old Maximum Storage 4200 that made those cartridges, but I do have a 5200. It wasn't hooked up at the moment, but that turned out to be simple enough. I stuffed the card into the Cheetah 386/25, put the MAXSYS retrieval software in CONFIG.SYS, and turned things on. Voilà. It took about 20 seconds to copy the relevant subdirectory to the Cheetah's hard disk, another 20 seconds to use the LANtastic network to send them on to the 486/33, and about half an hour to generate the reports for the IRS. Counting the time it took to connect up the WORM drive, it was an hour and a half total. Not bad.

The disadvantage of WORM drives is the cost of the medium. A DAT costs $13.95 at Tower Records and will hold 2 gigabytes of data. A WORM cartridge holds 600 MB and costs nearly $100. Clearly, you'll store more on a DAT than on a WORM cartridge. On the other hand, you'll need the proper software, lest you overwrite what's already on the tape. Naturally, the WORM drive is much quicker (especially for restoring a single file); therefore, it's more convenient.

The latest Maximum Storage drive, the Duette System 6, is a dual drive like the Pioneer read/write optical drive: the same drive makes WORM or read/write optical records. The medium cost is a bit lower than for the old WORM only, but it's still a few dollars per megabyte, as opposed to about a penny a megabyte for a DAT.

While I'm at it: Colorado Memory Systems makes really neat tape backup units, such as the 120-MB DJ-10. These units use data tape rather than DAT. While a typical DAT system will run $3000 or more, Colorado Memory tape drives start at under $200. Tapes hold tens of megabytes rather than gigabytes, and both archiving and restoring are considerably slower than with either a WORM drive or the Palindrome DAT. But the Colorado

Memory units work, they're easily installed, and they're one heck of a lot better than trying to back up onto floppy disks.

And yet another possibility: a portable hard drive that works through the parallel port. The Flashdrive from BSE (which I talked about in my February column) works just fine, and it can be used to transfer files from one machine to another. It was intended for portables, but it works with anything. Moreover, the software is pretty smart: if it doesn't see a Flashdrive out there on boot-up, it doesn't install itself. When the drive is hooked up to the printer port, reboot, and voilà! Intel is working on a "super parallel port chip," so that technology is likely to get a lot better in the future. The Flashdrive is another recipient of a User's Choice Award.

All told, there's no longer any excuse for not backing up your work.

The Troubles Begin

So: I had Windows 3.1 running on my Cheetah 486/33. I had all my backup systems in place. Things were sluggish with the old Quadram VGA board (good and reliable, mind you, but not designed for Windows) and the Zenith FTM, but that would be no problem. All I needed was a good Windows graphics board.

I first tried the Graphics Ultra board from ATI Technologies. After all, it works wonderfully well in the Cheetah 486/25 in the other room. It speeds Windows up

All told, there's no longer any excuse for not backing up your work.

something wonderful and installs with no hitch at all. Best of all, I have two ATI boards. This was going to be a snap.

Alas, the Graphics Ultra wouldn't work in the Cheetah 486/33. It showed, onscreen in VGA monochrome mode, a diagram of itself with its video processor chip blinking and shrieked that it had a fatal error.

Well, all right. Possibly the Zenith FTM wasn't fast enough. The Graphics Ultra is set for the monitor type through software that reprograms an EEPROM on the board. Of course, that means the board must be in a computer that's working—and since the computer couldn't boot with that board, I would never get it reprogrammed. Mind you, the other Graphics Ultra continues to work wonderfully on the 486/25, but that isn't broke....

I next installed the Sota Lightning VGA board. This has switches and jumpers to set the kind of monitor. Came up just fine. Windows looked good on the Zenith FTM.

Alas, I had real problems with driver installation. The Sota software comes on 5¼-inch disks. Installing it overwrites parts of the Microsoft Windows Setup program files. So when you go to Setup to install new video drivers, Windows will request files from the original Windows installation disks to be put in drive A. Those, alas, are 3½-inch disks, and they can't be put in the A drive; and since you're in the middle of a program, you can't use ASSIGN to get around the problem. Eventually, a member of the Microsoft technical-support team called and told me how to manually get the files off the distribution disks and expand them into the WINDOWS\SYSTEM directory.

Things took off. It looked like Windows was working just fine. Elated, I was.

Windows Pains

I'd celebrated too soon. Windows worked for nearly a day, and then came a horrible crash. I'd be typing along, and suddenly the machine would lock up. Then it might do nothing for a while and spontaneously recover; or it would lock up and stay locked until hardware reset; or it would begin to redraw the screen, *slowly* and painfully, taking more than a minute, and then start doing it again. Or...

Whatever it did, it wasn't consistent. I sent in trouble reports to Microsoft.

They responded heroically. Given the thousands of test sites, I'm amazed at their ability to keep up with bug reports. (Imagine a roomful of patient scribes, goose quills in hand, candlestick telephones stuck in their ears....) I prepared a complete report on my hardware with a listing of all my .INI files, CONFIG.SYS, and so forth. They made suggestions. I tried them. Some helped: now it might be an hour or two before the system would lock up. That just made things worse.

This went on for weeks, right through the holidays, with column deadlines and books to finish. Naturally, I wasn't using Windows for my work. I'd fire up the machine under Desqview, get things done, and then try Windows again. I was getting used to Ascend, with its daily record, journal, task priorities, and appointment schedule. There were other Windows applications I liked. I suppose there was also some perverse incentive to like Windows simply because I couldn't have it.

Anyway, I kept reporting problems, Microsoft would make suggestions, I'd try them, and the system would crash again.

Some New Light

At this point, NEC sent their wonderful new MultiSync 4FG Monitor. This has a display area of 8 by 11 inches, larger than that of the Zenith FTM. The monitor is a handsome thing, solidly built, with the controls in front where they belong—no reaching around back to tweak it, not that it has needed much tweaking. You can vary the display size with buttons on the front control panel: expand it to fill the entire tube face, or shrink it down to postcard size. No matter what you do, the images are sharp and clear. This is one great monitor.

There's one difficulty. My office faces south and I sit facing north, meaning there's a very bright window behind me. That wasn't important with the Zenith FTM, which has the greatest antiglare provisions I have ever seen. With the MultiSync 4FG it's not so good. I may have to ask NEC for their optional polarizing filter. However, while I very much liked the near absence of glare with the Zenith FTM, I find that in the last few days I have been getting used to the crisp display on the MultiSync 4FG. In another week, I may not notice any glare. We'll see.

Jiggle, Jiggle

I was eager to install the MultiSync 4FG for two reasons. First, I wasn't dead sure the Windows lockup problems weren't caused by the Sota Lightning VGA board; after all, the problems started just after I had trouble installing its drivers. The problem was, the Sota board was the only fast video board I had that would work with

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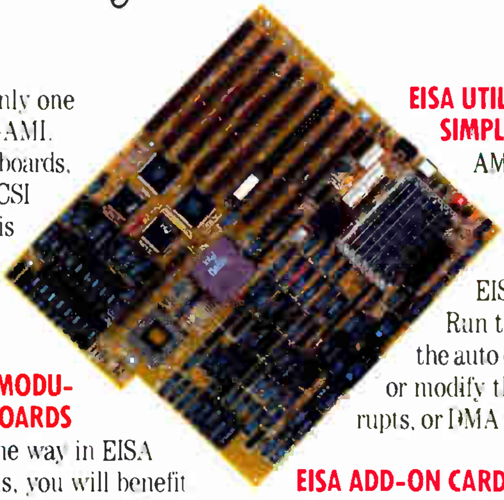

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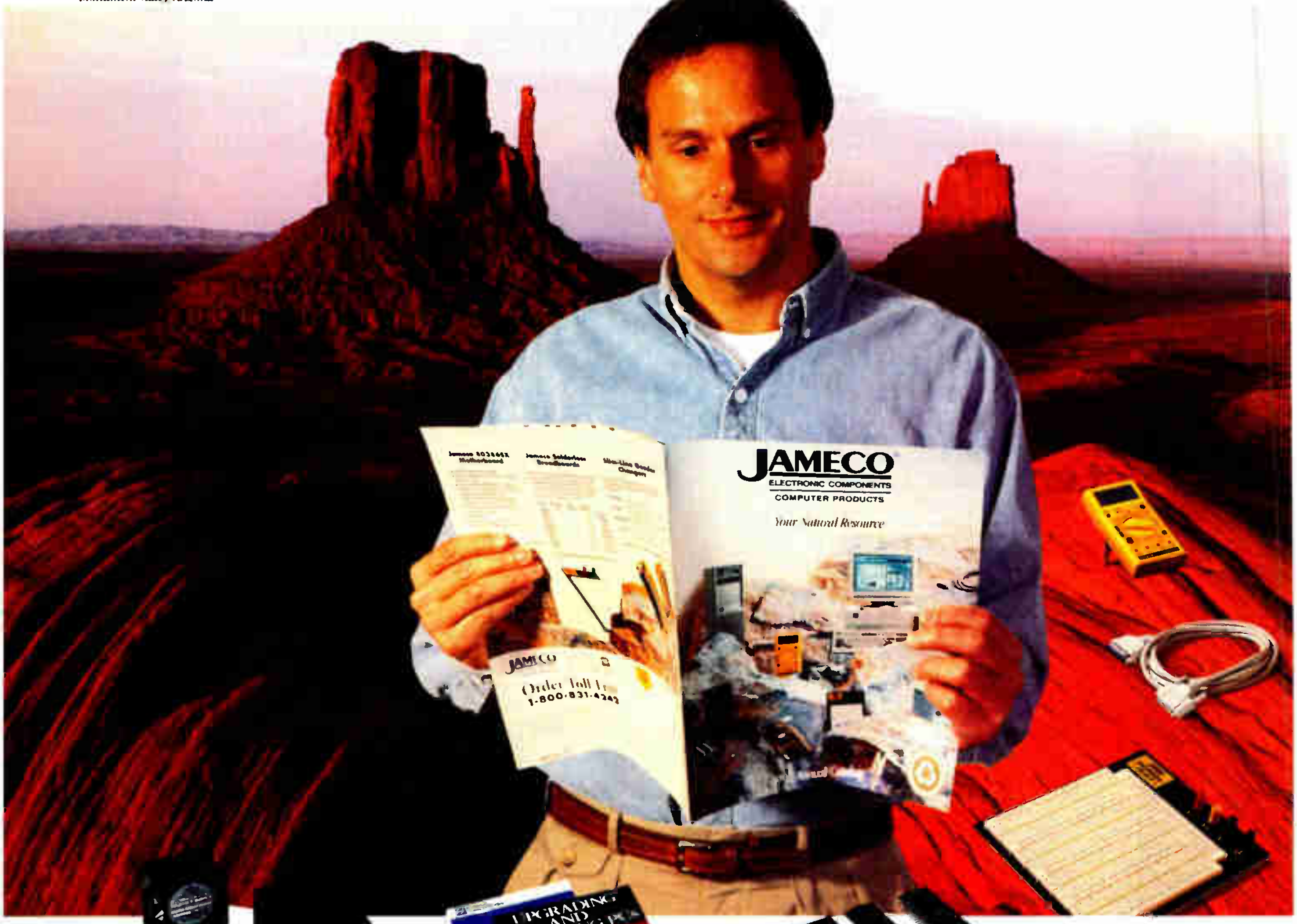

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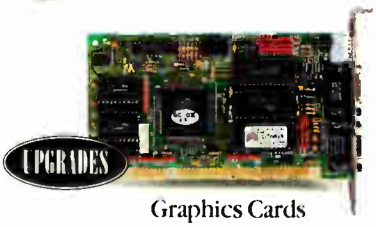

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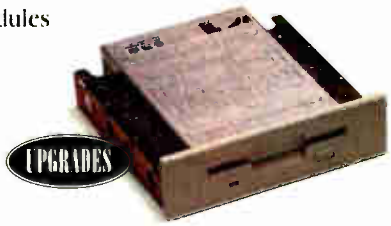

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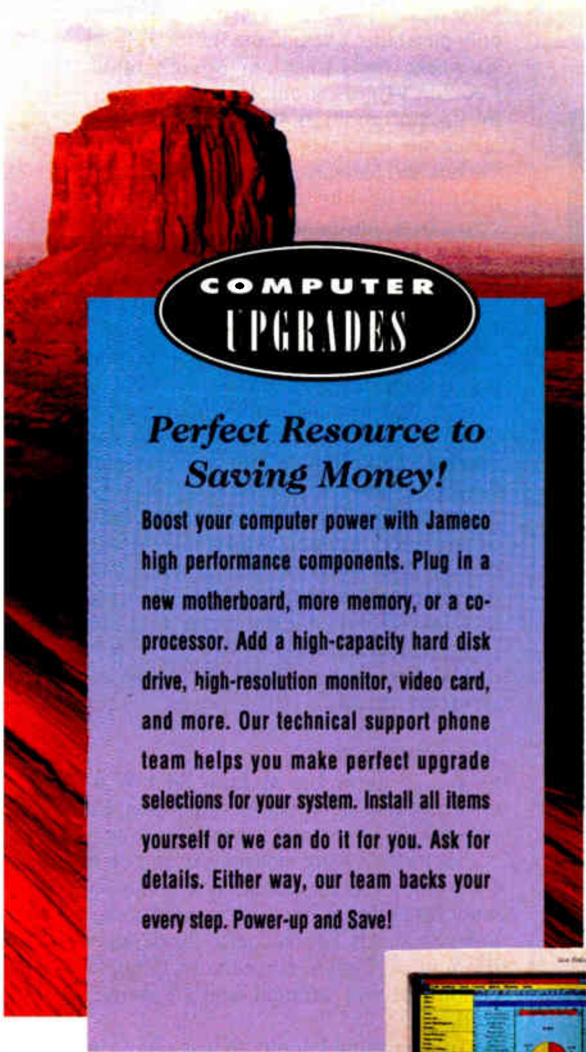

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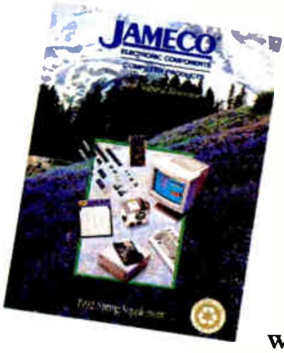

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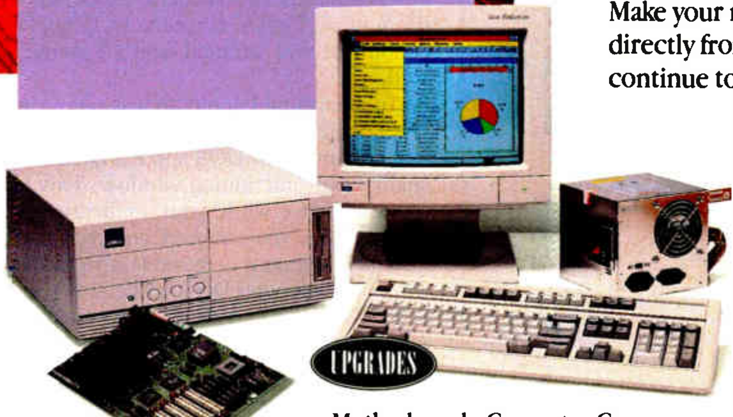

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the Zenith FTM. Until I had a faster monitor, I wouldn't be able to change video boards. Now that I had the MultiSync 4FG, I could try other things.

Second, there was something wrong with the Zenith FTM. I've had it for years, and it's always worked splendidly. Since the FTM has a refresh rate of only 31.5 kHz, it can be used only in 640- by 480-pixel resolution, but that was no disaster. With Windows at that resolution, the desktop is cluttered and you'd like more room to scatter icons on, but 640 by 480 pixels is more than good enough.

But one day the monitor developed a definite jiggle. Lines of text were wavering. It was particularly severe over on the right side, but there was some motion everywhere. I couldn't deal with that for very long.

Alex thought the monitor was getting old. Time to send it to a shop for tweaking. Nothing serious, but it really ought to be looked at.

I took the Zenith FTM off my computer desk and wrestled the MultiSync 4FG into place. The image came up on-screen just fine—and it jiggled, about as bad as it did on the FTM.

Aha, I thought, another strike against the Sota board: Out it went, to be replaced by an STB Wind/X board. I connected it, plugged in the monitor, and turned it on—and watched it jiggle. It wasn't the Sota board at all.

At that point I should have known. I can only plead that I've had the flu for the past six weeks, and I wasn't in my right mind. I couldn't figure it out. Was it the open-tower-configuration 486 computer down under the desk? Move the monitor off to the left and forward, away from the computer. The jiggling stopped. Hmm. Put the cover back on the computer. All's well. Push the monitor back away from the front edge of the desk. Jiggle, jiggle.

CD-ROM drive? Speakers? What in the world?

When I built this office, I had wall plugs put in 4 feet off the floor so I wouldn't have to crawl around under the furniture. One of those was squarely behind the monitor, and plugged into it was one of those little power-converter things the size of a matchbox. This one powered the Seiko Smart Label Printer. Apparently it had been well behaved for years and then one day gave up and started radiating, because as soon as I pulled it out of the wall, the jiggling stopped, and the MultiSync 4FG display became as solid as if it was painted on the screen.

Pain and Gain

So far, so good; but an hour later Windows crashed again. Same symptoms: I'd be working along, and it would lock up.

The lockups were recoverable, sort of: if I were in a DOS application (I generally was) when things crashed, I could sometimes do an Alt-Tab and get to the desktop. From there, I could close the DOS application that was jammed, and all seemed well.

Another thing I could do was type Alt-Enter, which in Windows' enhanced mode will collapse your DOS application into a smaller but functioning window. This is useful because while your application is in that mode, you can mark and copy text into the Clipboard or paste text from the Clipboard into your DOS application window. This works even if the application doesn't know about mice. I use that method to squirt text from the Windows Notepad into a DOS Procomm window and thus out on-line to BIX.

In this situation with the application locked, though, Alt-Enter did nothing. But

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USER'S COLUMN

if I then did Ctrl-Alt-Del, the familiar three-finger salute, things would happen. First, the screen would turn to garbage. This was Windows presenting me with a message. I'm not sure what it was, but the proper response was to press Esc. Windows would trundle for a moment, and voilà! There would be my DOS application nicely reduced to a window size, running as naturally as if it hadn't ever locked up. Alas, 5 minutes later I'd have to do that again. Clearly, this wasn't any way to get my work done.

The result was that I'd run Desqview. If I wanted Windows, I'd run it in a Desqview window. Not a permanent solution, of course.

Then Desqview crashed.

The Plot Thickens

Desqview didn't exactly crash, but it exhibited a weirdness I had never seen before. I'd be running a communications program and downloading lots of text. Suddenly, the screen would turn to goo: instead of text scrolling by, there would be lines of question marks, blinking color patterns, and other garbage. The thing was, if I pressed the Alt key, which triggers Desqview, the screen would become normal again; meanwhile, the text that had come in and gone to disk was perfectly normal.

Clearly, something was wrong here. First I thought it was the Zenith FTM (this was back when I was putting up with the jiggle). Then it happened on the MultiSync 4FG. Changing video boards didn't fix it, either.

Must be the new version of QEMM-386, I thought. I dumped version 6.02 and went back to 6.00. No joy. All problems remained.

It was time to quit thrashing about and use some intelligence.

The Mystery Solved

When IBM first designed the PC, in their Big Blue wisdom they decided that no one would ever want more than 640 KB of memory. After all, the PC was replacing CP/M systems that had a maximum of 64 KB.

Actually, I suspect IBM knew better. I think the PC, like the PCjr, was designed crippled with the notion that IBM would later talk you into scrapping it for a "real" machine. Recall that in those days the PCs were from the Entry Systems Division. They were the bait: you'd get hooked, and when you ran up against the PC's limits, you'd buy something else.

That's pure speculation. But whatever the motive, the PC was deliberately designed to make it nearly impossible to use

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more than 640 KB of memory, and DOS was accordingly limited. DOS could address a full megabyte, which left an area between 640 KB and 1 MB; that area of memory was filled with bits and pieces of stuff needed to get information into and out of your computer. The result of this has been headaches for everyone, because that area between 640 KB and 1 MB, known as the upper memory area, is terribly useful.

Memory managers like 386Max and QEMM-386 use this area as a way station to access memory above 1 MB. The video ROM, which controls what's sent to the screen and how, is addressed there. System ROM is stuffed in there. Network cards are addressed there.

If two devices want the same block of that memory, you get problems.

Fine. Now what devices had I? Early on, I'd taken out every card in the system and still had the problem. Well, not *every* card, because the system wouldn't operate without a video card. And there had to be a drive controller.

Oh.

The HyperStore controller needs an 8-KB block of address space, which by default is addressed to C800, which is a hexadecimal address. If you don't understand *hexadecimal*, don't worry about it. It's a big number pronounced "See-eight-hundred." That controller had been operating in my system for nearly a year with no problems, so I had pretty well forgotten it was there.

More important, I had forgotten that it *had* an address. I pored over the HyperStore documents to find that not only is there an address, but it can be changed with jumpers. Right there on the bottom of the page telling how to do that is this: "Warning: In most cases, the primary address of the HyperStore will perform with no complications. If the system has a 512-KB VGA card, it may be necessary to set the HyperStore address to D800."

That's one triumph of understatement. I hope to kiss a duck it may be necessary to set the HyperStore address to D800...

Once that was done, the primary problem vanished. There are still some residual difficulties, which I'll get to another time.

The moral of the story is that PCs are badly designed. Why the devil should users have to do hexadecimal addressing to use a machine that costs more than a computer-controlled washer/dryer? When I buy major appliances, someone comes out and installs them and shows me how to use them. For PCs, there are badly written manuals I can go through to find that if I add a 512-KB VGA card, I "may" have to change a jumper to readdress a card from C800 to D800.

More on this another time. At least Windows 3.1 wasn't at fault. It still has some minor bugs, and there are a few significant interactions between video cards, monitors, and software. But I am finally past the point where all the interactions are significant, and I can get on with using Windows, which is, in fact, a joy to use.

The Big Orchid

Last month, I ran out of space before I could present my Orchid of the Year, so I'll do it here: the Chaos Manor Orchid of the Year goes to Philippe Kahn, chairman/CEO of Borland International. A generic User's Choice Award goes to Borland International in general. That doesn't mean I endorse every product the company makes; but by gollies, I have yet to find one I wouldn't recommend.

Borland handled the dBase/Ashton-Tate affair very well. They put poor old

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Fully integrated menu-driven software program offers ease of installation and operation!	YES	NO
Advanced Compression Utility Tool Kit scans, checks, and repairs compressed data!	YES	NO
Advanced Disk Optimization Utility defragments or consolidates compressed data for optimal disk performance!	YES	NO
Highest compression ratio of any data compression software (up to 25% greater with version 2.0!).	YES	NO
Automatically updates CONFIG.SYS on physical partition to further enhance transparent operation!	YES	NO
Dynamically adjusts drive capacity to fit more data on compressed disks with less effort!	YES	NO
Performance enhancing Disk Cache results in faster system performance!	YES	YES
Device driver easily loads high, maximizing conventional memory for RAM-intensive applications!	YES	YES

Circle 151 on Inquiry Card.

mishandled A-T out of their misery. Since my original review of Vulcan back in CP/M days was responsible for George Tate's founding A-T and converting Vulcan to dBase II, I had a personal interest in what happened to the people who used dBase on my recommendation. I'm happy to say that Borland has treated them well.

Borland's big professional C++ compiler is the proper compiler for any C programs: it contains much more error checking than any other C compiler I know of, and it will ask you if you *really* want to do some of the very odd things the C language allows. Their Turbo line, particularly Turbo C++, is the most painless way to find out about new languages. Both Borland C++ and Turbo C++ get User's Choice Awards. The company's support and upgrade paths for the original Pascal have been superb. I've no hesitation to hand Philippe Kahn in particular—and Borland in general—the Orchid of the Year.

Onions

So many people deserve onions that I despair. We have car manufacturers who want the government to come down hard on Japan for not buying cars Americans won't buy. We have a government that has not the faintest notion of what kind of trade war we're in. (The Japanese used what they called "hostile trade" against China in the twelfth century, but I doubt anyone in Washington knows that.) We have a corporate structure that eliminates hundreds of thousands of jobs to accumulate the money to pay its executives millions a year for presiding over the fiasco. The list of those deserving large onions is endless.

So many people deserve onions that I despair.

On reflection, though, the biggest and smelliest onion goes to the regulators who use red tape and obfuscation to strangle start-up companies in their cradle. The FCC is probably the major offender: they don't care if your product puts out annoying radiation or not. (To wit, the toy transformer for the Seiko Smart Label Printer.) All they care about is whether you paid your tribute to get your certification, and if you didn't, they will harass you from the showroom floor to the ends of the earth. A well-deserved Chaos Manor Onion with Garlic Clusters to the FCC, which has done as much to bash American competitiveness as anyone I know.

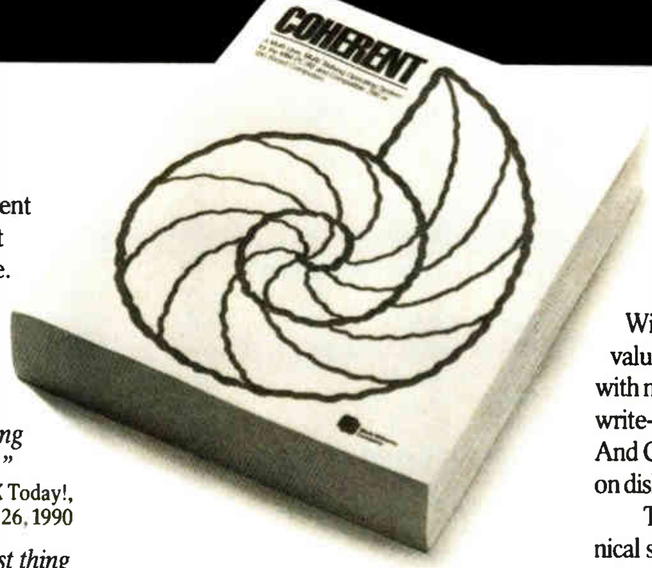
Winding Down

The book of the month is *Shooting Blanks: War-Making That Doesn't Work* by James F. Dunnigan and Albert A. Nofi (Morrow, 1991), an excellent compendium of dumb military tricks. The computer book of the month has been Brian Livingston's *Windows 3 Secrets* (IDG Books, 1991), and yes, I know it was mentioned last month as well. *Windows 3 Secrets* also contains the shareware of the month: there are two disks of freeware and shareware for Windows users.

continued

"I can't believe it's not UNIX."

–Sean Fulton, UNIX Today!



Take it from the critics, Coherent is so close to UNIX, you won't believe your eyes. Or the price.

"Mark Williams Co. seems to have mastered the art of illusion; Coherent comes so fully qualified as a UNIX clone, you find yourself thinking 'I can't believe it's not UNIX.'"
–Sean Fulton, UNIX Today!, November 26, 1990

"...(Coherent) may be the best thing that has happened to UNIX yet."
–William Zachmann, PC Week, November 5, 1990

"If you want to come as close as you can to real UNIX for a low price, COHERENT can't be beat."
–Warren Keuffel, Computer Language Magazine, November 1990

"If you want a UNIX-like development and learning system for less than $100...I don't see how you can go wrong with Coherent."
–David Fiedler, BYTE Magazine, November 1990

OVER 30,000 USERS, AND MORE EVERY DAY!

Why is Coherent now the world's best-selling UNIX clone?

	MWC COHERENT Version 3.2	SCO XENIX 286 Version 2.3.2.
No. of Manuals	1	8
No. of Disks	5	21
Kernel Size	64K	198K
Install Time	20-30 min.	3-4 hours
Suggested Disk Space	10 meg	30 meg
Min. Memory Required	640K	1-2 meg
Performance*	38.7 sec	100.3 sec
Price	$99.95	$1495.00

*Byte Execl benchmark, 1000 iterations on 20 MHZ 386.
Hardware requirements: 1.2 meg 5¼" or 1.4 meg 3½" floppy, and hard disk.

NEW RELEASE 3.2

$99.95*

Because like the original UNIX, Coherent is a powerful, multi-user, multi-tasking development system with a complete UNIX-compatible kernel and C compiler.

Features include Lex and Yacc, a vi editor, SCSI support and UUCP capabilities.

And Coherent comes with a full set of over 200 UNIX commands including text processing, program development, administrative and maintenance functions. All of it fully documented in our highly acclaimed 1200 page manual.

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Unlike current versions of UNIX, Coherent is lean and efficient. Small and beautifully powerful, the way UNIX was originally designed.

Coherent runs on affordable 286 as well as 386 and 486 based IBM-PCs and compatibles with space to spare. Enough space to keep DOS co-residing on your hard disk.

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- A new Korn shell with sophisticated command-line editing.
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TAKE 60 DAYS TO CONVINCE YOURSELF.

Will you agree with the critics and Coherent's 25,000-plus users?

Try it. And if you don't think Coherent is everything you ever wanted in UNIX, we'll refund your money. No problem. No hassle.

You can't go wrong. So get to a phone, FAX or mailbox now and order Coherent today. At $99.95, it's unbelievable.

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ITEMS DISCUSSED

Ascend $299
NewQuest Technologies, Inc.
2550 South Decker Lake Blvd.
Salt Lake City, UT 84119
(800) 877-1814
(801) 975-9992
fax: (801) 975-9995
Circle 1146 on Inquiry Card.

Civilization $69.95
MicroProse Software, Inc.
180 Lakefront Dr.
Hunt Valley, MD 21030
(410) 771-1151
Circle 1147 on Inquiry Card.

DJ-10 ....$250
Colorado Memory Systems, Inc.
800 South Taft Ave.
Loveland, CO 80537
(800) 432-5858
(303) 669-8000
fax: (303) 667-0997
Circle 1148 on Inquiry Card.

Duette System 6 ....$3875
Maximum Storage, Inc.
5025 Centennial Blvd.
Colorado Springs, CO 80919
(800) 843-6299
(719) 531-6888
fax: (719) 531-0227
Circle 1149 on Inquiry Card.

HyperStore 1600 ....$650
Perceptive Solutions, Inc.
2700 Flora St.
Dallas, TX 75201
(800) 486-3278
(214) 954-1774
fax: (214) 953-1774
Circle 1150 on Inquiry Card.

Microsoft Windows 3.1
(price not available)
Microsoft Corp.
1 Microsoft Way
Redmond, WA 98052
(800) 426-9400
(206) 882-8080
fax: (206) 883-8101
Circle 1151 on Inquiry Card.

MultiSync 4FG $949
NEC Technologies, Inc.
1255 Michael Dr.
Wood Dale, IL 60191
(800) 632-4636
Circle 1152 on Inquiry Card.

OS/2 2.0 ....$195
IBM Corp.
(800) 342-6672
Circle 1153 on Inquiry Card.

Q&A 4.0 ....$399
Symantec Corp.
10201 Torre Ave.
Cupertino, CA 95014
(800) 228-4122
(408) 253-9600
fax: (408) 253-4092
Circle 1154 on Inquiry Card.

QEMM-386 6.02 ....$99.95
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(800) 354-3222
(213) 392-9851
fax: (213) 399-3802
Circle 1155 on Inquiry Card.

Rules of Engagement $59.95
Mindcraft
2341 205th St.
Torrance, CA 90501
(213) 320-5215
Circle 1156 on Inquiry Card.

Sota Lightning VGA $445
Sota Technology, Inc.
559 Weddell Dr.
Sunnyvale, CA 94089
(800) 933-7682
(408) 745-1111
fax: (408) 745-1640
Circle 1157 on Inquiry Card.

Wind/X $439
STB Systems, Inc.
6151 North Glenville, Suite 210
Richardson, TX 75081
(800) 234-4334
(214) 234-8750
fax: (214) 234-1306
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USER'S CHOICE AWARDS

Borland C++ 3.0 ....$495
Turbo C++ $99.95
Borland International, Inc.
P.O. Box 660001
1800 Green Hills Rd.
Scotts Valley, CA 95066
(800) 331-0877
(408) 438-8400
fax: (408) 439-9344
Circle 1159 on Inquiry Card.

Flashdrive $499
The BSE Company
1622 Edinger Ave., Suite F
Tustin, CA 92680
(714) 258-8722
fax: (714) 258-8815
Circle 1160 on Inquiry Card.

Network Archivist $995
Palindrome Corp.
850 East Diehl Rd.
Naperville, IL 60563
(708) 505-3300
fax: (708) 505-7917
Circle 1161 on Inquiry Card.

Since I've been sick, I tried a number of new games, but I haven't found any I like better than Civilization (MicroProse Software) and Rules of Engagement (Mindcraft).

CD-ROMs of the month are from Wayzata Technology (P.O. Box 807, Grand Rapids, MN 56744, (800) 735-7321). They include Pictures of the Universe, a year's worth of *Insight*, and other stuff; get their catalog.

Incidentally, you can now send in four SyQuest disk cartridges and for $250 have an indexed CD-ROM made from their contents. This is less than the cost of the four disk cartridges and is clearly the wave of the future.

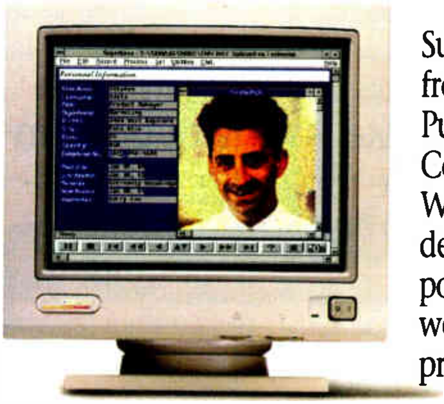
I'm out of space, and I still didn't get to the Brave New Worlds I promised last time; next month for sure. Also next month: computers for college—hardware and software to send with the kids. Outfitting a Mac or a PC for academia. There will also be a lot more on Windows. And I have finally received a copy of OS/2 from IBM. ■

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. You can also contact him on BIX as "jerryp."

About the only thing Superbase 4 can't contain is your imagination.

Imagine this.

A Windows™ database that can handle virtually any data type.



It's called Superbase® 4 from Software Publishing Corporation. With it, the development possibilities are, well, thought provoking.

Consider bar coding. Think creatively and anything's fair game. One high-security prison, for example, uses Superbase 4 to keep track of their prisoners.

Or how about video? Through DLL you can store still shots from a full-motion video camera. Or grab key images from a previously recorded tape.

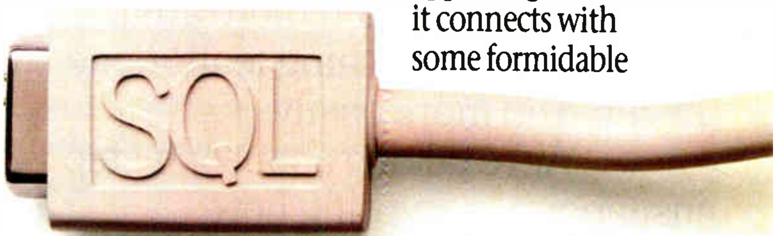
What's more, any photographic or graphic image can be included in any data file. So you can dress up product

catalogs. Personnel records. You name it.

And through DDE you can even pull in everyday business accessories. Like maps, graphs, charts, and spreadsheets.

MICROSOFT WINDOWS

But this versatility doesn't come at the expense of power. Superbase 4 is fast. It lets you include an unlimited number of characters in any text field. And supporting SQL, it connects with some formidable



databases—SQL Server, Oracle, Sybase, dBase, and DB2, among others.

In fact, Superbase 4 already manages a direct mail database containing over one million records. It could handle a lot more.

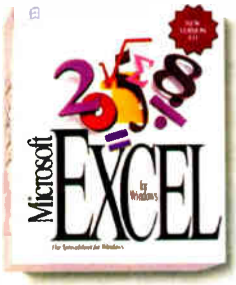
So it's no wonder Superbase 4 is the worldwide market leader in Windows databases.

Just imagine what it can do for you.

SPC SOFTWARE PUBLISHING CORPORATION

Imagine, a free demo disk just by calling 1-800-336-8360, Operator 626.

Why consider a new you can leave we



Microsoft Excel 4.0, the spreadsheet for Windows.

Because well enough just might not be good enough anymore.

Because new Microsoft® Excel 4.0 for Windows™ is the ultimate refinement of a powerful, easy-to-use spreadsheet.

Because you could be getting your day-to-day spreadsheet tasks, not to mention more amazing number-crunching feats, done faster. And more easily.

We're talking about one-step just-about-everything here.

Take a feature like Autoformat: with just a click of your mouse, it applies one of 14 sharp-looking, professionally designed formats to your worksheet.

Or consider Autofill, which intelligently helps you build your worksheets. For example, when you type January in a cell, Autofill automatically enters February, March, April—as many (or as few) months ahead as you designate.

Shortcut menus are another innovation. When you click the right mouse button, a menu appears on-screen next to whatever you're doing, offering you all the options that sensibly relate to the task at hand.

Wizards are step-by-step guides that take you through complex tasks, like charting, or creat-

The Scenario Manager is a powerful analysis tool that lets you easily create and save multiple "what if" scenarios, then instantly produce nice-looking summary reports. (Which makes you look nice, too.)

ing summary tables from a database, with incredible ease.

And with new Drag and Drop, all you do is highlight the area you want to move, "grab" it with your cursor, and drag and

See your reseller for details. 'Offer good only in the 50 United States through 7/31/92. For information only: In Canada, call (800) 563-9048; outside the 50 United States, call (206) 936-8661. Print

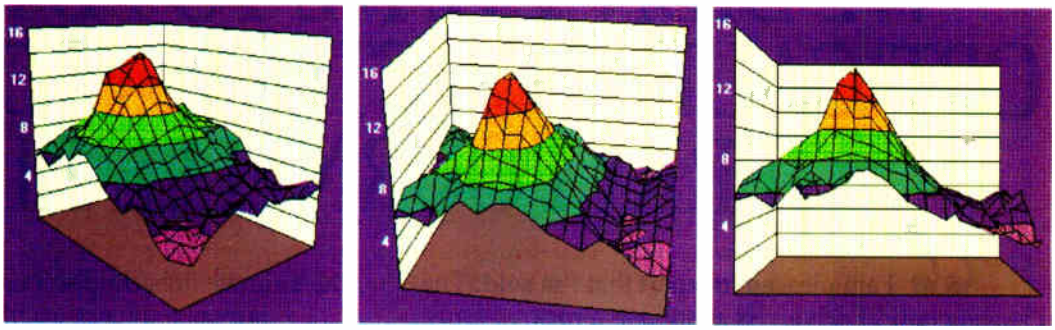
spreadsheet when ll enough alone?

drop it to wherever you want it on your screen. It's that simple.

We've also made the Toolbar customizable. Plus, it has handy new features, such as a Spelling Checker and AutoCenter, which lets you center text over multiple columns with a single click of your mouse.

Invested a lot of time in Lotus®? That's no problem. You can learn using what you know. Type in your familiar Lotus 1-2-3® commands, and Microsoft Excel shows you the equivalent commands. Easy.

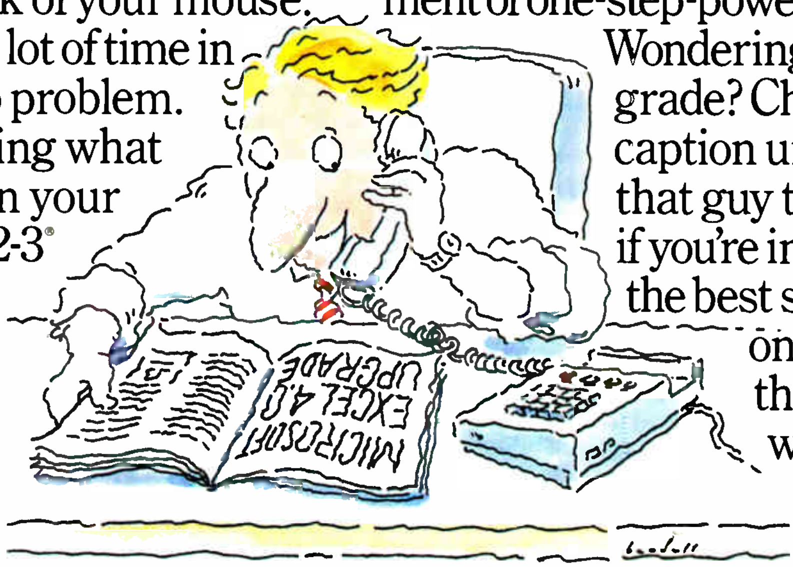
Microsoft Excel also reads and writes your Lotus files. And it runs your macros–unmodified. It even comes with a convenient 90-day money-back guarantee.*



The gallery of 90 chart types includes rotating 3-D charts, along with surface, radar and picture charts. It looks great here. It's even more impressive on your screen.

By now, you may agree with us that new Microsoft Excel 4.0 for Windows is the ultimate refinement of one-step-power-with-ease.

Wondering how to upgrade? Check out the caption underneath that guy to your left–if you're interested in the best spreadsheet on the planet, that is. Otherwise, just try to forget you ever saw this.



Even upgrading is easy. It's $99 for current Microsoft Excel users, and $129 if you're using Lotus 1-2-3 or Borland® Quattro® Pro†. Call us at (800) 323-3577, Dept. Y61, to order yours. Or see your local software reseller.

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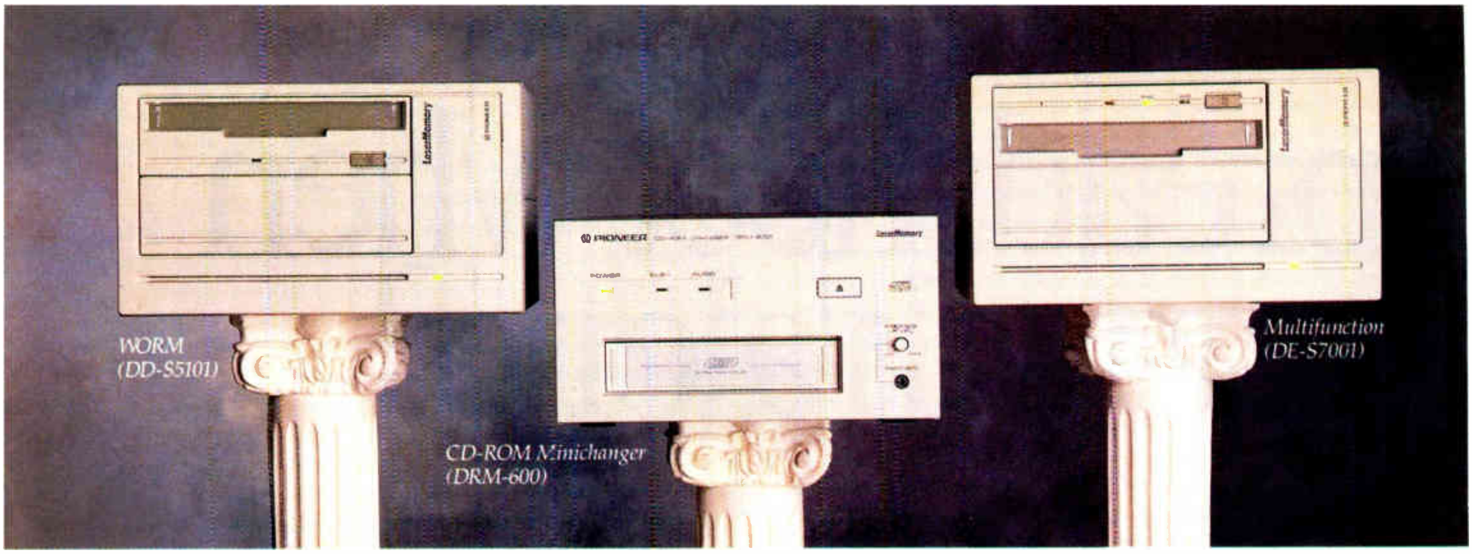

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"I am pleased to report that I'm sold. The Pioneeer optical drive... is as solid as a rock.** . . . Thus, I'm discontinuing testing. Now I'll just use the drive. . . . I now rely on the Pioneer erasable optical disks for backup, for primary storage of really big files, and for archive copies of software . . . you really need something **so easy** to use that you'll routinely use it for backup . . . **the Pioneer DE-S7001 will do the job very well indeed. Recommended.** *Byte (9/91)*

The Pioneer six-pack CD-ROM Minichanger is great. We've had it in operation for the best part of the year now, on a number of different systems. . . . **It has always performed flawlessly** . . . it changes drives a lot faster than you'd expect it to. . . . **It's really fast.** . . . Accesses that used to take many seconds are now nearly instantaneous. Accesses that took over a minute now take a few seconds. **I always did like the Minichanger.** . . . **Now it's even better.** . . . Incidentally, the Pioneer Minichanger will work just fine with a Mac. *Byte (10/91)*

The Pioneer DE-S7001 dual-purpose external optical disk drive I've written about before. Log your wordprocessor to that, save early and often, and you'll have it all. . . . In a word, WORM drives look like **the ultimate in backup storage.** *Byte (12/91)*

Suppose you erase a file? Overwrite one you wanted to keep? And suppose your house burned down? You don't have any off-site backup at all. . . . **I could remedy that by installing the DE-S7001 on the network server and archiving on that.** . . . *Byte (11/91)*

I have the DRM-600 running not only with QEMM386.SYS, but inside DESQview windows, which has the amusing result that I can actually have several CD-ROM windows open at once. . . . **It's surprising** how fast you can switch back and forth among them. . . . The Pioneer DRM-600 . . . **it's very convenient** to have a bunch of CD-ROMs available without swapping. *Byte (1/91)*

It's quite intuitive [the Pioneer CD-ROM Minichanger]: no instructions are required. . . . **Recommended.** *Byte (1/91)*

This technology is coming of age. *Byte (1/91)*"

JERRY POURNELLE
RENOWNED COMPUTER COLUMNIST

For more information or for a free VHS videotape "Pioneering The Future," about Pioneer optical disk products, call 1-800-LASER-ON, and find out why Pioneer is the leader in optical disk technology.

PIONEER

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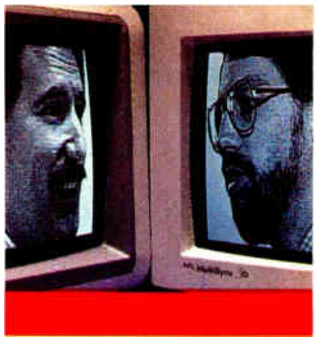

BYTE editors debate the issues with contributors, readers, and industry experts

MAKING SENSE OF MULTIMEDIA

Roundtable is a forum in which BYTE editors, contributors, readers, and industry experts debate key issues that affect how you purchase and use hardware and software. The "conversations" take place on BIX, where you can participate in the round.table conference.

Editor's note: *This month, BYTE invited multimedia software and hardware developers to discuss the technology's practical applications. BYTE Multimedia Lab director Tom Yager moderated the discussion.*

Why should average users care about multimedia? With millions of desktops worldwide playing host to common general-purpose applications, what can multimedia bring to the broadest class of desktop computer users?

CARL CALABRIA: The average user should not care about multimedia, nor any other enabling technology. What is important is that the technology allows them to do what they could not do before or that it allows them to do something better than they did before. The great promise of multimedia technology is its ability to enhance the way people *communicate* with each other and with the machines that serve them.

RICK STAUFFER: I agree. People will adopt multimedia with motion video and audio because it makes communication better and easier. Users will perceive value in presentations, desktop information, and video communications.

I have given traditional presentations with overheads and 35mm slides and full multimedia presentations. My experience is that audiences respond more, and more positively, to multimedia presentations.

Providers and users of desktop software will also see great value in multimedia. Right now, people with desktop PCs use a limited number of software packages and a limited number of capabilities within those packages. Embedding training right into the product reduces one key obstacle to obtaining new users.

The PC is catching on as a communications tool, as witnessed by the explosion in E-mail. Audio-phone mail offers advantages in that you don't have to use the keyboard and you get the emotion in the voice. Video E-mail and video conferencing go one step further with facial expressions and posture.

ED JUGE: People shouldn't care about how multimedia technology works, but they absolutely care about the benefits it provides. People retain more information when the transfer involves more senses. One of our strategic partners showed images to people, asking them to rank the quality of the images on a scale of 1 to 10. Some were shown with accompanying background music. (Those with music varied from test subject to test subject.) The images with music ranked consistently higher.

MIKE BRAUN
Assistant General Manager, Multimedia
IBM Corp.

CARL CALABRIA
Director of Engineering
Truevision, Inc.

ROB GLASER
Product Group Manager, Multimedia Systems
Microsoft Corp.

ED JUGE
Director of Product Marketing
Tandy Corp.

RICK STAUFFER
Marketing Manager
Intel Corp.

Will there be a "killer application" that pushes multimedia into widespread commercial success? If so, what type of product will it be, and how long do you think we'll have to wait?

CALABRIA: A small number of applications will propel multimedia into the mainstream. I see a product called VideoMaker that, when used with the appropriate multimedia technology, will enable true desktop video publishing. VideoMaker will let you create a video from start to finish. It will offer templates for common video formats (e.g., sales presentation, trip report, product demonstration, and training tape). These templates will provide a storyboard that you can customize.

Once you complete the storyboard, the application will generate a list of video and audio sequences that you will capture (e.g., 10 seconds of product footage, 30 seconds of testimonial, and 2 minutes of background music). You can augment the captured audio and video with clip art, clip video, and clip audio to provide richer content. The application will place these elements in a storyboard time line. You can fine-tune the editing, add graphics and text overlays, select different transitions, and add special effects.

Because the content will be in digital format, you will be able to manipulate and process it to produce almost any desired result. When pleased with the result, you will either transmit it digitally or output it to videotape. Although I don't think a killer application is necessary to propel multimedia into a widespread commercial success, I do think that desktop conferencing will be a killer application. By desktop conferencing, I mean the ability to do collaborative work using all media.

ROB GLASER: In the business/productivity area, there will be a few categories that benefit quickly from multimedia technologies—presentation graphics is one obvious one. A second is E-mail—the ability to record and integrate voice and video easily will be a short-term benefit. Voice will happen first because it requires fewer bits and little hardware. Also, it's easy to digitize.

Outside the business arena there will be very compelling applications that drive the creation of new categories of systems. Let's not call these computers (although that's what they'll be on the inside); instead, let's call them digital appliances.

There will be many digital appliances (e.g., AT&T's new picturephones, personal communicators, electronic book readers, and digital entertainment systems). In some of these cases, the "application" is built into the device (e.g., the picturephone, which is just a two-way multimedia pipe). In other cases, there will not be one killer application as much as a whole genre, such as Microsoft's Multimedia Beethoven or Broderbund's new Living Books. Individual titles will probably cost less than $50, but there will be so many that people will be willing to spend the hundreds of dollars required to buy the device that plays the titles. This is much more like the model that established audio CD players.

How important are cross-platform multimedia standards (e.g., data representation and application programming interfaces)? Is multimedia so compelling that it will draw new users to computers, or existing users away from their current systems to those more suitable for multimedia applications?

MIKE BRAUN: Standards are an integral part of allowing application creators to flourish. IBM has worked closely with Apple and Microsoft to reach common formats. But the issue of standards transcends operating systems. We need standard formats for publishing media, for interconnecting devices, and for packaging titles.

GLASER: Having a standards infrastructure is important for two reasons: Multimedia is a communications technology that requires a lingua franca, and many interesting multimedia applications will work on new digital appliances. For these appliances to become popular, they have to be cheap and consumers have to have confidence that they won't get stuck. Many people bought beta VCRs and remember when their local video rental outlet stopped carrying beta videotapes.

Microsoft established a standard mechanism for plugging time-based media into Windows 3.1. It's called Media Control Interface. IBM has stated that it plans to implement MCI in the OS/2 multimedia subsystem.

MCI is a general-purpose mechanism—it provides a core set of commands and allows for commands specific to a class of device. One area that we're working in now is establishing a common command set for digital video, be it software-only video (e.g., Microsoft's Audio Video Interleave, or AVI) or hardware-assisted video (e.g., Intel's DVI). We've worked closely with a number of companies, including Intel and Fluent, and have a draft version of the specification out for review.

JUGE: Without standards, the software industry won't be able to devote sufficient resources to development to reach critical mass. The MPC standard has joined manufacturers representing more than one-quarter of the PCs sold in the U.S. and has given developers a single target platform. MPC represents a minimum standard, not a closed-end platform, and more advanced technologies can be layered on top of it for more demanding applications. It also assures buyers that an application carrying the seal will play on their computer.

What is the future of integrating moving video as a data type? Should users invest in relatively inexpensive computer-controllable video gear and video overlay cards, or should they wait until digital video steps in and makes outbound gear obsolete?

GLASER: The big fork in the road is between digital video and analog video. Midterm to long-term, I come down on the side of digital video. The main reason is flexibility. Computer users assume that any computer-controlled data type will be editable, shippable to other users, easily stored, embedded in a range of applications, and so on. Digital video makes all those functions possible.

Within digital video is a second fork between hardware-assisted compressors/

ROUNDTABLE

decompressors and software-only codecs. Intel's DVI and the upcoming Moving Pictures Experts Group standard are examples of hardware-assisted codecs. These are expensive, but they enable full-screen, 30-frame-per-second video at CD-ROM data rates (i.e., 150 KBps). Most people who have seen well-produced hardware-assisted digital video rate it as at least equivalent to broadcast NTSC or VHS.

Software-only codecs such as AVI (toolkits to ship by the middle of this year) and the codec that's part of Apple's QuickTime do not do 30-fps full-screen video—at least not from an arbitrary data source. But they do have the economic advantage of working on a large percentage of today's PCs.

Software-only codecs also make it reasonable to ship video to other users. While there are still issues with this (video chews through hard disk space), software-only video schemes will educate users about what they can do with video and will stimulate creativity, much as BASIC made it easy for millions of PC users to program. For professional applications, most people will eventually want 30-fps full-screen video. But we as an industry need to get the ball rolling for video as a ubiquitous data type.

CALABRIA: The VCR represents as nearly a ubiquitous delivery platform as our society has today. The NTSC, PAL, and SECAM broadcast channels of the world represent the ultimate wide-area network. Cable TV also represents a huge bandwidth pipeline into countless homes. This represents excellent motivation for connecting the computer to the analog video world.

Outbound video gear will never be obsolete. What's more, the advances in multimedia technology will only serve to expand the need to interface with external analog gear. When $200 computers can deliver full-motion video and stereo hi-fi audio for hours at a time on a medium that costs less than a dollar, I will agree that analog technology is obsolete.

My advice to buyers contemplating the purchase of computer-controllable video gear and video overlay cards is to purchase products that can solve the problems they have today. A quality computer-controlled VCR or videodisc player will serve them well into the future, even with the migration toward an all-digital computer video environment. If a "video in a window" overlay card provides you with a solution today, buy it. It will be no more obsolete than the computer into which you install it. Three years from now, both will be in the trash. ■

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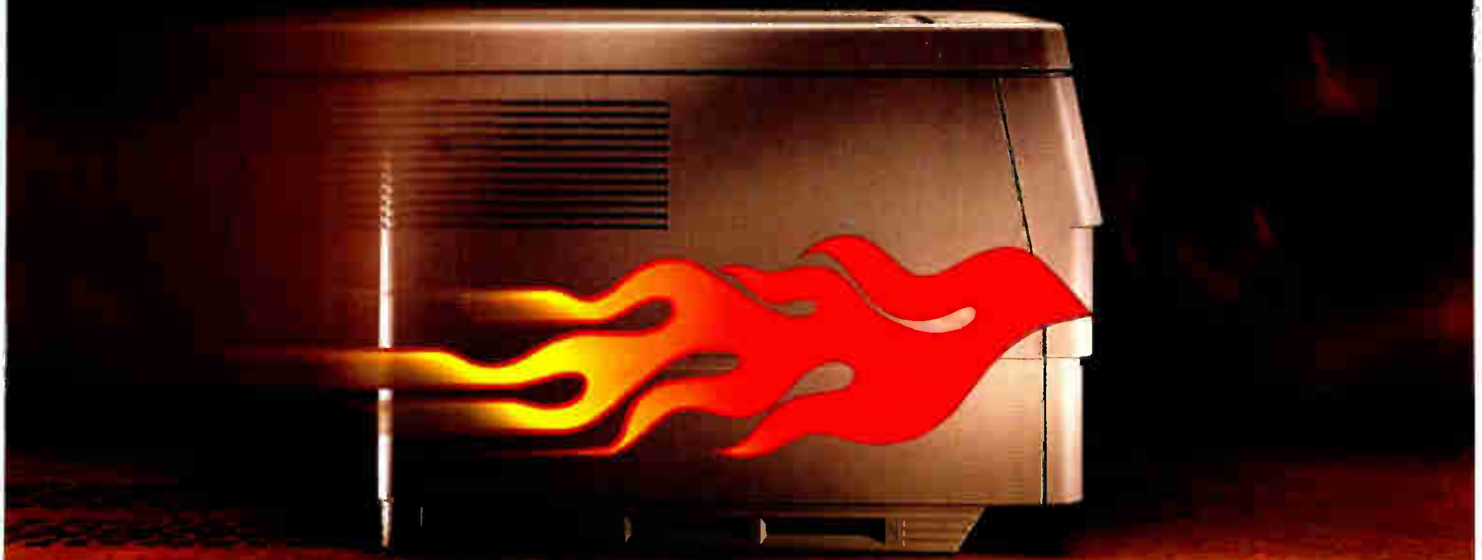

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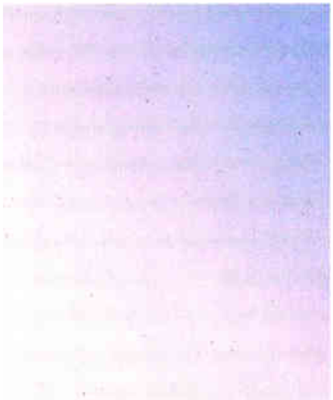

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COVER STORY

FEATURE

Intel's Double-Fast CPUs

Working at 50 MHz internally and 25 MHz externally, the Intel 486DX2 is both powerful and economical

BARRY NANCE

Despite the uncertainties that surround the PC industry, one factor has remained constant since the introduction of IBM's first PC: Every time the industry raises the standard in computing power, it lowers the price/performance ratio—a streak that even DiMaggio could envy. You may not know whether you should commit to Windows or OS/2, but you do know that your next machine will provide more power per dollar spent than your last one.

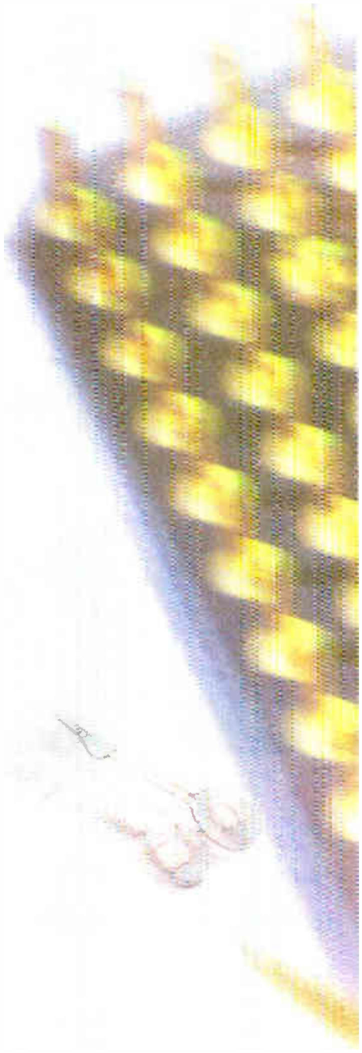
During the past 12 months, there has been disquieting news on the price/performance front. The current high-end CPU in the PC world—Intel's 50-MHz 486—has proven to be a difficult taskmaster. Designing and building 50-MHz motherboards is a complex and expensive task, which means higher prices at the retail level. The constantly dropping price/performance ratio, considered almost a birthright among PC users, was in jeopardy.

Impatient for motherboard manufacturers to design faster systems to handle faster CPU chips, Intel has taken matters into its own hands. Instead of coaxing motherboard makers into the difficult job of creating designs that support 50-MHz, 66-MHz, and higher-speed CPUs, Intel has engineered a 486 chip—the DX2—that operates internally at twice the clock speed of the rest of the system, which operates at its "normal" speed.

Doubling the internal clock speed of a 486 can add significantly to the performance of a system without adding significantly to its overall cost. The 50-MHz 486DX2 works with existing 25-MHz motherboard designs yet—for many kinds of software—performs substantially better than a 25-MHz 486 and somewhat better than a 33-MHz 486. Later this year, Intel plans to release a 66-MHz 486DX2 that requires motherboard components rated at 33 MHz. Until the P5 CPU becomes a reality late this year or (more probably) early next year, DX2 clock-doubling

BYTE ACTION SUMMARY

Intel's 50-MHz 486DX2 runs on 25-MHz motherboards. It thus provides most of the advantages of 50-MHz systems without their cost and design complexity. Used as either a factory-installed CPU or as a customer-installed Intel Overdrive Processor, DX2 technology works best with high-performance memory systems.



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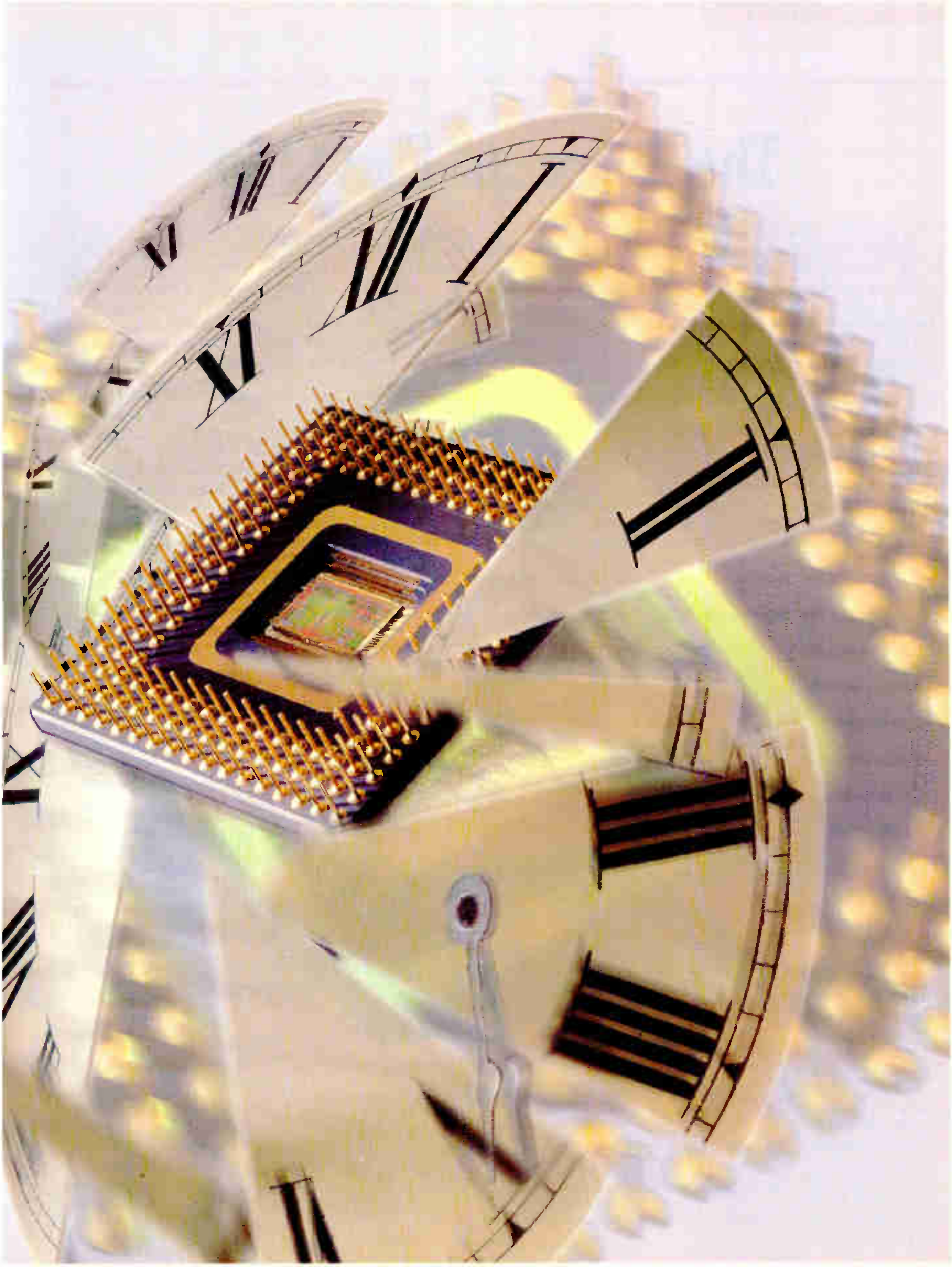


The Twice-as-Fast Chip

The DX2 is exactly like all previous 486DX chips, except that it runs twice as fast internally. The bus-interface portion of the CPU chip produces a 2-to-1 "gear reduction" action. When the DX2 CPU accesses its internal registers, refers to a memory location already mapped into its internal cache, or performs a floating-point operation, the CPU works at the faster rate.

But when the CPU has to access main memory, do I/O instructions to an adapter card, or access one of the other chips on the motherboard, the DX2's electrical signals through the bus occur at half speed (i.e., 25 MHz for a 50-MHz DX2). The DX2 waits for the currently executing instruction to do its off-chip work before continuing with the next instruction. The figure shows this relationship. The DX2 talks to the keyboard controller, the 8259 programmable interrupt controller, the timer chip, the external cache, the DMA controller, the RAM chips, and the adapter cards at the slower rate. The RAM chips, the video adapter memory, and the unshadowed ROM BIOS memory may insert additional wait states, as well.

The high level of integration of a 486 makes clock doubling worthwhile. The internal 8-KB cache of the 486 CPU, along with the on-board math unit and the memory management unit, handles enough of the workload to let you realize gains from the faster internal clock speed. Depending on the software you run, the CPU often finds it can use the contents of the internal cache.

For DOS software, the hit rate is about 90 percent to 95 percent. The internal cache organization is four-way set associative; the cache holds four 2-KB blocks, each containing 128 lines of 16 bytes each. These occur in 128 sets of four lines each.

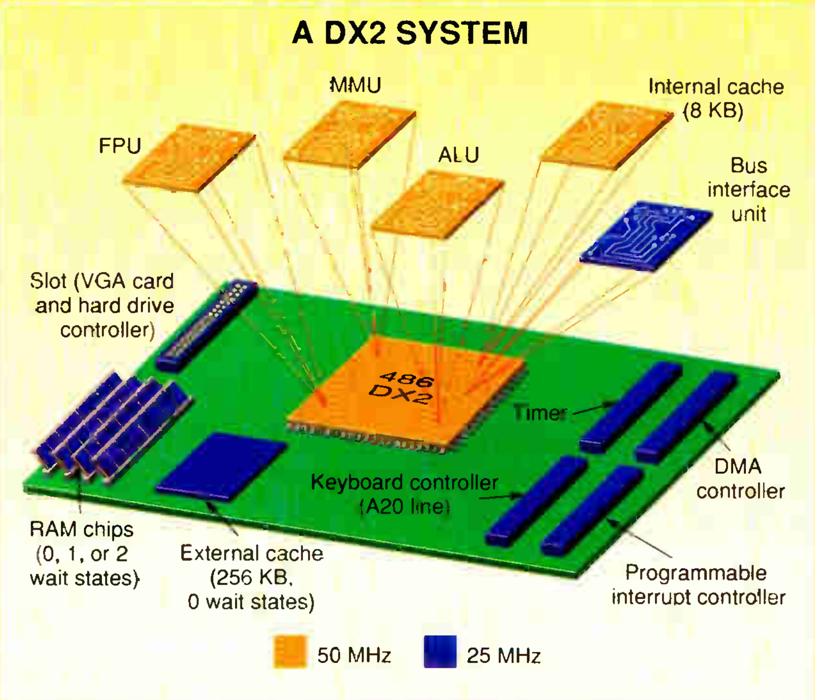
Basically, this organization allows the cache to hold several noncontiguous memory locations at the same time. Writes to main memory are write-through, but the 486 buffers up to four writes before storing updated values in RAM. The result is that the 486 can do quite a bit of work before having to talk to the rest of the motherboard.

Does this mean you can pop out your old 25-MHz 486 and replace it with a 50-MHz DX2? Not necessarily. The 50-MHz DX2 consumes about 40 percent more power than a 33-MHz 486DX and generates correspondingly more heat, so you'll need to make sure you can dissipate the extra thermal energy of the DX2.

Also, the software subroutines in the ROM BIOS of your 25-MHz 486 CPU may contain timing dependencies. The DX2 will access the ROM BIOS code at the proper rate (25 MHz), but the BIOS routines may get confused when some instructions appear to operate faster than usual. Nonetheless, Intel expects that motherboard manufacturers will be able to substitute a DX2 in place of a DX chip with little or no change to the motherboard.

Don't expect to see clock-doubled 386 chips, as the gains in performance would be much less dramatic than with the 486. The 386 uses an external math coprocessor and an external cache, and the CPU must go off-chip to accomplish virtually everything. A clock-doubled 386 would show performance gains for certain instructions, such as register-to-register operations, but not for anything else.

In the future, you can expect to see Intel triple, and even quadruple, the internal speed of the 486. With much beyond that, however, bus saturation mitigates the advantages of faster internal clocks.



The bus interface unit of the DX2 processor forms the divide between 50-MHz and 25-MHz operation on a DX2 system. The BIU uses the CLK signal from the motherboard timer to drive its operation; all other parts of the CPU use 2×CLK.

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technology is Intel's path to better performance (see the text box "The Twice-as-Fast Chip" on page 116).

The Impact of the DX2

What makes the DX2 significant? First, in its 66-MHz incarnation, it will be the fastest CPU chip for PC compatibles during much of 1992. Power users who like fast computers will naturally buy DX2-equipped machines. In general, you'll find that DOS, Windows, Unix, and OS/2 2.0 applications run faster on a DX2 CPU. You won't have to pay for a redesigned motherboard to get the extra performance, because the DX2 is almost always a "plug-and-play" replacement for a 25-MHz 486 chip.

Second, the DX2 represents the end of an era. The DX2 technology will likely be the last to use the ISA bus. As Trevor Marshall pointed out in his article "System Bus or System Bottleneck?" (March BYTE), transmission-line effects and signal quality set the speed limit for a bus, and design becomes more difficult near the upper limits. The expense and effort it takes to design an ISA-bus 486 motherboard that operates at 50 MHz or higher are significant. The DX2 lets motherboard makers squeeze higher performance from existing, relatively low-cost designs.

Tale of the Tape

As you'd expect, benchmark tests (see the text box "A Tale of Two Tandys" on page 120) show the 50-MHz DX2 to be faster than a 25-MHz 486, although the performance of the DX2 is limited in the tests by the lack of any secondary cache in the test systems. The BYTE DOS benchmarks quantify performance with actual numbers, but I wanted to go beyond the benchmark numbers to get a feeling for how the DX2 performs in ordinary situations. For my experiments, I used a Northgate Elegance ZXP computer containing a 486DX2 processor.

I wrote a couple of small assembly language programs to deliberately show what the DX2 can do. The first program simply read the same location from memory over and over again. I looped through that instruction several million times, knowing that the DX2 would find that same location in its internal cache each time. As you'd expect, the DX2 achieved 50-MHz performance as it executed the loop of instructions.

The second program accesses memory outside the internal 8-KB cache during each loop. From this second program, I observed performance that showed the DX2 operating at slightly better than 25 MHz—just about what you'd expect in this situation.

After exploring the boundaries of DX2 performance, I got down to some real-world tests. I added 12 MB of RAM and installed Novell NetWare 3.11 in the Northgate to see how the DX2 would perform in a file server. Not surprisingly, the 50-MHz DX2-equipped Northgate outperformed a 33-MHz 486 server by a slim margin. I made sure that the NetWare 3.11 disk cache held the data I read from a remote workstation. I concluded that the DX2 is a good candidate for use in a file server.

After replacing the Northgate's NetWare 3.11 with OS/2 2.0, I exercised OS/2 on the DX2. It ran substantially faster. In particular, the graphics operations that update the screen appeared to be faster with the DX2. Windows was also faster.

I found another noticeable difference between the DX2 and earlier 486 CPUs, too: The DX2 runs hotter. A heat sink will be de rigueur on DX2 motherboards.

Considering a DX2 System

In many instances, because the DX2 eliminates the CPU as a bottleneck in the computer, it puts a premium on high-speed components. It goes without saying that a fast hard drive is important, but unless you use the DX2 machine as a file server, you'll want to pay attention to the video adapter.

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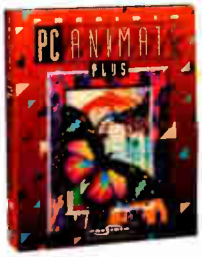

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A Tale of Two Tandys

RICK GREHAN

In the August 1990 BYTE (see "386SX PCs: Heirs to the Low End"), the BYTE Lab became acquainted with the unique design of the Tandy 4016 SX's hinged case: Once you remove its plastic outer shell, you reveal a metallic sheath that opens into two sections, each swinging up and out like gull wings to expose the motherboard. The Tandy 4825 SX and 4850 EP machines are similarly designed—appearing as if Tandy has simply slipped new motherboards into a 4016 SX housing—although their internals are a far cry from those we found in the 4016 SX.

Common traits are that both the 4825 SX and the 4850 EP are 25-MHz 486 machines (although, as you've probably guessed, the 4825 houses a 486SX processor). Both come standard with 4 MB of RAM, expandable to 32 MB on the motherboard, and have three 16-bit ISA slots available. Each has 512 KB of video RAM on the motherboard, and four 20-pin sockets let you upgrade video memory to 1 MB for support of a 1024- by 768-pixel 256-color mode.

The standard drive configuration for these machines is a single 3½-inch 1.44-MB floppy drive and a 120-MB SmartDrive (i.e., a Tandy IDE drive). Both machines are accompanied by a healthy software entourage: Windows 3.1, MS-DOS 5.0, and Microsoft Works 2.0. Both systems have all the basic I/O that most users will ever need: two serial ports, a parallel port, a PS/2-style mouse port, and a VGA adapter. In case you're worried about all the I/O consuming the ISA slots, don't be; the I/O circuitry is on the motherboard.

Speed Is the Difference

In fact, a cruise around the inside of both machines shows that they are identical but for one thing: the CPU. The 4825 SX houses a 25-MHz 486SX with an optional 487SX coprocessor (which we did not have available in our test machine). Inside the 4850 EP, however (see the photo), is a 486 whose heart beats at twice

Tandy's new 4850 EP uses Intel's double-clocked 486DX2 to boost performance.

the expected rate. Intel's clock-doubling technology allows the 4850 EP's CPU to march in double time whenever the current instruction is one that the CPU can deal with on-chip.

To explore the performance of both machines and to reveal any advantages provided by the 4860 EP's clock-doubled CPU, we ran both machines through the BYTE low-level and application-level benchmarks. Overall, the performance of the 4825 SX is unimpressive. When we examined the BYTE benchmark results, we saw that it performs from 7 percent to 15 percent poorer than a Compaq Deskpro 486/25. (We are, of course, ignoring the Compaq's floating-point performance in this comparison, since the Tandy 4825 SX that we tested did not include a 487SX coprocessor.) In particular, the Compaq Deskpro did far better than the Tandy machine in functions that put heavy demands on memory throughput.

Happily, the picture changes when you examine the performance results of the 4850 EP. The chip-doubler technology gives the 4850 EP a substantial boost in CPU-intensive performance. For example, the BYTE Sieve, Sort, and Integer Math benchmarks show the 4850 EP as executing about 2.3 times faster than a Deskpro 486/25.

However, when you look at memory-intensive operations, the 4850 EP does little better than the 4825 SX. (The 4850 EP does appear to be able to handle odd-address accesses better than the 4825 SX, although even odd-address accesses on the 4850 EP are slower than on the Compaq Deskpro.) The reason is obvious: Operations that require moving data in and out of the CPU don't reap the benefits of the chip-doubler technology. The Compaq's superior performance in memory-move operations is doubtlessly due to that machine's 128-KB second-level cache (the Tandy has only the 486's 8-KB cache to call on).

The effect of the chip-doubler technology on the execution of applications—where, presumably, the instruction mix is more evenly distributed than it is in BYTE's low-level benchmarks—is difficult to predict by examining the performance of sieves and string moves. Fortunately, we also ran the BYTE application benchmarks on both Tandys, and this gave us a good idea of real-world performance. Overall, it appears that the 4850 EP runs about 1.3 times faster than its cousin. (Again, in fairness to the 4825 SX's lack of a math coprocessor, we are not including floating-point operations in this comparison.)

What Price Speed?

Given that the internals of both machines are identical, does it make buying sense to choose the 4850 EP over the 4825 SX? The answer is that if you scale price and performance equally, you'll just about break even.

The standard configuration for a 4825 SX (like the one we tested in the BYTE Lab) costs $1999; a 4850 EP in the same configuration sells for $2699. That's a ratio of 1.35—close to the performance ratio we saw in the application benchmarks.

Rick Grehan is technical director of the BYTE Lab. He has a B.S. in physics and applied mathematics and an M.S. in mathematics/computer science. You can reach him on BIX as "rick_g."

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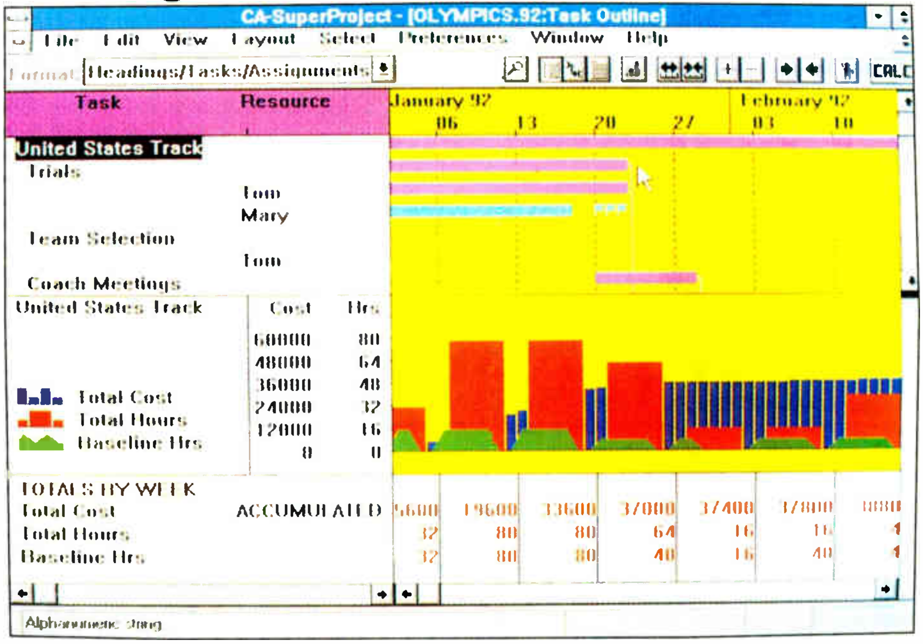

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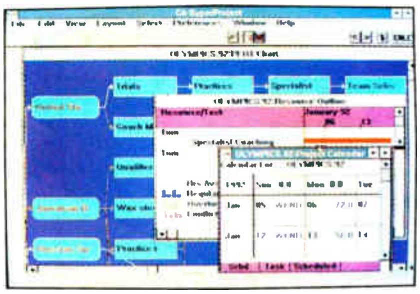

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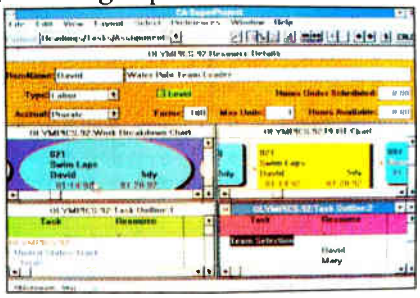

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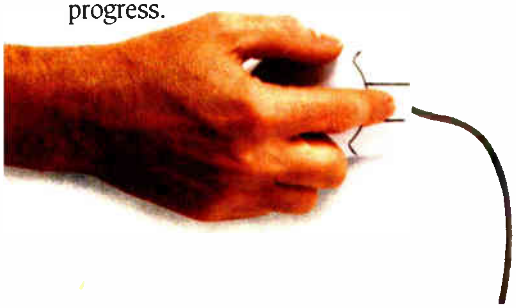

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The most important thing to look for in a DX2 computer is a well-designed and well-implemented memory system. The faster a system can get data and instructions into the clock-doubled CPU, the better performance you should see. According to Will Slope, marketing manager of Intel's Workgroup Computing Division, the DX2 will enhance the impact of a well-designed memory system.

This means you'll want to make sure that a DX2 CPU is augmented with a large external cache. A 64-KB cache is a bare necessity, and 256 KB is better. The CPU will very often find what it is looking for in the external cache if the 8-KB internal cache doesn't contain the appropriate memory location.

In general, you'll see better performance from most software when you run it on a DX2 machine. Applications that use a math coprocessor are prime candidates for DX2 technology, because the FPU in the 486DX2 runs at the doubled rate. On the other hand, you'll find that text-mode word processors and file-oriented database management software benefit little or not at all from DX2 technology.

Of Processors and Upgrades

The DX2 is an important component of Intel's corporate marketing strategy. Throughout its 386SL and 486 product lines, Intel is encouraging manufacturers to provide for the installation of an Overdrive Processor on every motherboard through the use of a second CPU socket. This will let you upgrade your system performance simply by purchasing and installing a higher-performance CPU. In this strategy, the 50-MHz 486DX2 is the natural upgrade for a 25-MHz 486DX, while the 66-MHz DX2 fulfills the same function for the 33-MHz DX. Thus, DX2 technology will find its way into two types of Intel products: as standard CPUs and, in upgrade form, as Overdrive Processors. DX2 CPUs will have a different pin-out from that of DX2 Overdrive Processors.

To implement this strategy, Intel plans to introduce dozens of variations of its 386SL, 486SX, 486DX, and 486DX2 chips this year. Its preliminary technical documentation for the DX2 suggests that it may extend this strategy to the P5, which could fill the role as an upgrade to the 50-MHz 486DX in addition to taking its place at the high end of the Intel CPU line.

For most current 486 users, the biggest immediate impact of DX2 technology will be as an upgrade to 486SX machines. Intel is making an Overdrive Processor that will fit into the 487 socket of 486SX machines. This Overdrive Processor is a DX2 that significantly improves the performance of a 486SX machine both by supplying the missing FPU functions and by doubling the internal clock of the CPU.

If you're buying a PC today and you want the fastest machine you can get, DX2 technology is for you. The 50-MHz DX requires a much more expensive motherboard and is not generally available. The DX2 requires less-expensive 25-MHz components on the motherboard. Price-wise, you can see that the 50-MHz DX2 is a good route to better performance. ■

Barry Nance, a consulting editor for BYTE and a programmer for the past 20 years, is the author of Using OS/2 2 *(Que, 1992),* Network Programming in C *(Que, 1990), and* Introduction to Networking *(Que, 1992). Barry is the exchange editor for the IBM Exchange on BIX, where you can reach him as "barryn."*

While the PC industry continues to talk about performance in terms of CPU and disk speed, we at Quarterdeck think the biggest issue for most users is getting rid of "out of memory" messages.

DX2 on the Job

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Hardware Compatibility	Satisfactory	Good	Satisfactory	Satisfactory	Good	Satisfactory
Reliability	Needs improvement	Satisfactory	Needs improvement	Satisfactory	Good	Needs improvement
Ease of Use	Satisfactory	Good	Satisfactory	Good	Good	Satisfactory
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Key to comparison table: Software compatibility is defined as the product's ability to run without problems with the operating systems PC Week Labs used in testing, MS-DOS 5.0, IBM PC DOS 5.0 and Microsoft Windows 3.0, and with a variety of application software, including Quarterdeck's DESQview 2.40, Xerox Ventura Publisher 3.0 for DOS, WordPerfect 5.1 and Artisoft's LANtastic 4.0. Hardware compatibility is defined as the programs's ability to run on PC Week Lab's test hardware platform, which included a 33MHz 486-based PC and a 25MHz 386-based IBM PS/2 Model 70. Reliability ratings are based on the successful and dependable performance of each operating system and application-software package under each memory manager. Ease of use is based on ease of installing and configuring each program, based on support for automatic loading features and the intuitive narure of the interface. Flexibility in managing memory is rated on the range and quality of the product's features in optimizing system performance and handling special-case installation. Quality of documentation is judged by the clarity, comprehensiveness and helpfulness of the documentation provided with the product, based on the organization of the manuals as well as the thoroughness of definitions, directions and explanations, and the inclusion of troubleshooting information.

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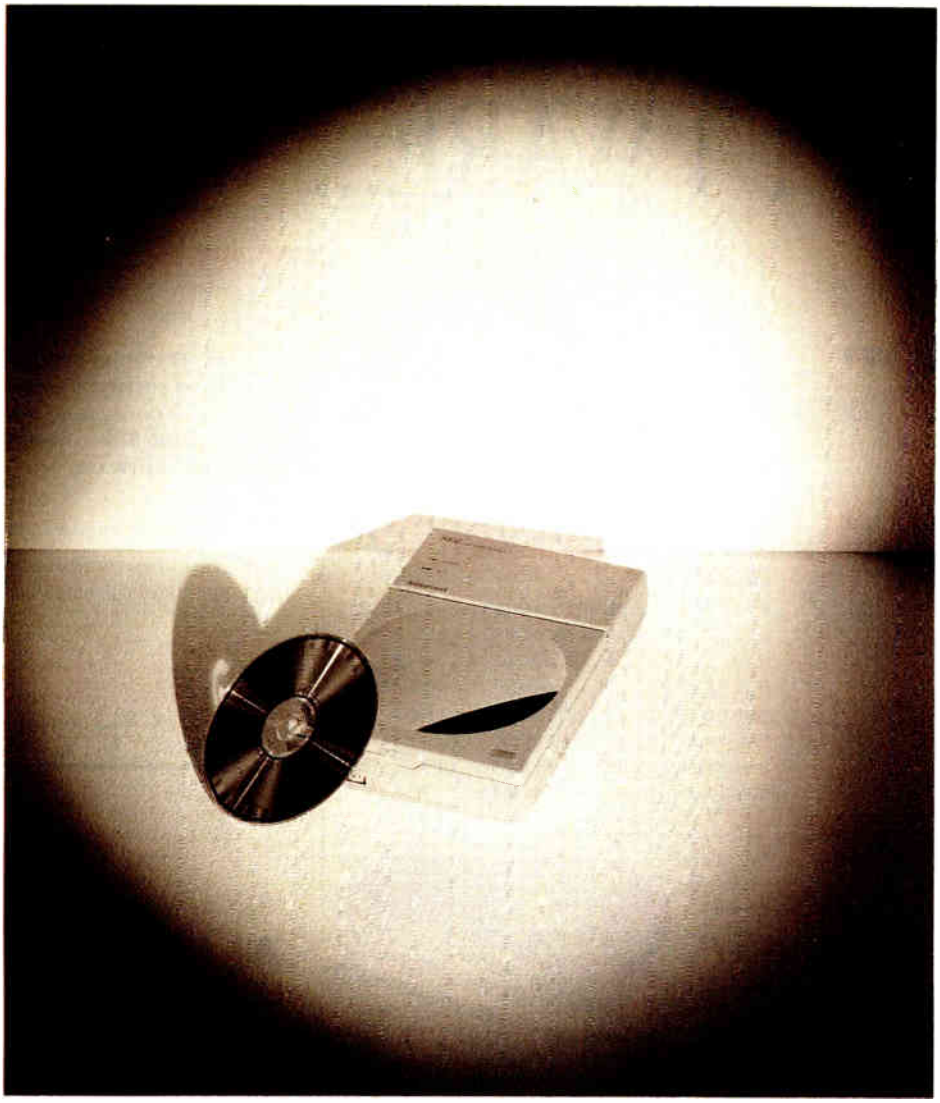

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FEATURE

PRACTICAL DESKTOP VIDEO, PART 2

Raw Material

Shooting good footage is a prerequisite for producing quality desktop video presentations

TOM YAGER

The availability of affordable computer-based tools makes desktop video production practical. But before you can begin creating that powerful video presentation on your desktop, you'll need one essential raw ingredient: good video source material. The quality of the video source material is critical, because no matter how skillfully you execute the rest of the production process, your presentation won't be effective if the video source material is poor.

Shooting video for professional use is, admittedly, more involved than shooting home videos, but it's well within the capabilities of the average computer user. Because the vast majority of people who are interested in creating business presentations aren't professional videographers, this article presents a crash course in planning and shooting professional-quality video. I'll also address supporting topics, such as what you'll shoot with and how the resulting video will fit in with your finished work. And I'll focus on solutions that are easy to manage and inexpensive yet capable of producing professional-quality results.

For the first project of this series, I'm shooting a video called "Inside the BYTE Lab." This short video is a good first choice since it is heavy on video but light on computer graphics and other elements that I'll get to later in the series.

Choosing Your Camera

Last month, the first article in this Practical Desktop Video series touched on video formats and the relationship between format and video quality. If you've read it, you may already know that I tend to favor high-band 8mm, or Hi8, as a convenient, high-quality acquisition format. There are plenty of choices in this arena, so I'll offer some tips about what to look for in a camcorder.

Even if you use the best editing equipment available, the video you shoot will never look as good in the finished work as it does when you play it directly from the original tape. That's because each time you copy a piece of video from one tape to another, it loses some of its quality.

Some generational decay is unavoidable (unless you use expensive digital gear), but you can minimize it by starting with the best video you can afford to create. That way, after it's been edited, mastered, and duplicated, the tape the audience sees will still look good. In my experience, video captured on Hi8 format by professional or high-end consumer gear has the strength to weather several generations of copying without turning to mush.

A good camcorder should have features that are useful for professional work. For example, you should look for an autofocus mechanism that's fast and quiet. If the camera is loaded with automatic features (and most cameras are), make sure you can disable those features when you need to.

The tapes produced by the camcorder should look and sound good to you. Record some tape and play it back through a properly adjusted monitor and sound system, using the camcorder for playback. Edges of objects should be sharp; solid colors should appear solid with a minimum of sparkling, or "swimming"; and colors in general should be bright without blurring or bleeding into one another. Audio should sound clear and crisp, with well-defined highs and lows.

In my hunt for the best camcorder for the job, I went through several candidates and picked two winners. The first is the Sony EVO-9100, an extremely solid Hi8 camcorder. Among its winning attributes is its built-in 8-mm time code, a huge help if you're planning to use Hi8 gear in the editing process; you often can pull the tape out of the camcorder and edit it directly. The other winner is the Canon

BYTE ACTION SUMMARY

A number of things go into the production of a professional-looking video: appropriate camcorder equipment, a plan, sound, lighting, composition, and variety. This crash course can lead you through the maze of options and help you create a video you'll be proud of.

A1 Digital, the unit I'm using now. This is a popular high-end consumer camcorder that includes an infrared remote control and a handful of digital special effects. It doesn't do time code, but it sports an excellent set of optics. It also has a Control-L remote-control port. The Control-L port looks like an ordinary pause-control jack, but it's actually a serial interface that allows an edit controller, computer, or other device to control the camcorder's functions.

Steady Now

When shooting for business use, a hand-held camcorder is your enemy rather than your friend. The problem is that your hand is attached to the rest of your body through a network of muscle and bone that is impossible to keep still. By far, the best video is shot with a camera that doesn't move except when you want it to.

In the battle to hold your camcorder steady, your first line of defense is a tripod. Like most video-related items, it's far too easy to overspend on this. A basic $50 tripod will give you most of what you need: It holds your camera still.

If you think you'll want to move around with your camcorder, you might consider the Steadicam JR. This device helps you carry your camcorder (provided it weighs less than 4 pounds) and hold it steady, but it offers much more than that. The device (see photo 1) consists of a perfectly balanced platform resting atop a handgrip. A gimbal mechanism maintains a single point of balance while allowing a wide range of motion. A monochrome LCD monitor displays the video and frees you from being glued to your camera's viewfinder.

Photo 1: *Cinema Products' Steadicam JR takes the jiggle out of hand-held shooting and even allows you to walk while taping. Its LCD monitor frees you from the camera's viewfinder.*

The Plan's the Thing

Those of us who grew up with TV take video production for granted. The expertise of the people who create the images we watch makes it all seem easy. And when you're shooting "video snapshots" on vacation or at a friend's wedding, it can be as simple as point and shoot. What video technology won't do for you, however, is the planning, and that's the element that often makes the difference between a professional-looking production and one that ends up looking like a local car dealer's ad.

You've probably seen storyboards in "The Making of..." documentaries. They're used to boil down the essence of a scene, and each hand-drawn frame usually depicts some event—a change in camera angle, the entrance of a new character, and so on. When a storyboard is drawn, it represents a vision of a scene in much the same way that sheet music represents a performance. No one can hear sheet music or see movement in a storyboard, but experienced people can look at these things and imagine how a finished work will sound or look.

Planning a video, like planning any large project, is best handled by breaking the task into pieces. Video divides well according to how most tapes are laid out. The broadest grouping of material is a *segment*. You can have several segments, but a short video (like "Inside the BYTE Lab") has only three: the opening, the main body, and the closing.

Each segment contains a number of *sequences*, each representing a complete idea (like a written paragraph). Sequences are groups of *scenes* that contribute to the idea, with a scene being (for our purposes) the amount of video that you shoot at one time. These definitions are a good start, but if you find a better way, use whatever works for you.

When you group things this way—segments, sequences, and scenes—a hierarchy begins to appear that suggests a natural way to organize your video: an outline. There are many ways to manage an outline, but it's best to do it on a computer.

I chose to use a tool specifically designed for the job: a product called More from Symantec. This Macintosh program has built-in outlining facilities that are well suited for planning videos (and it can create impressive presentation graphics).

The qualities of More that make it perfect for the job relate to its ability to gracefully accommodate the inevitable changes in your plan (even the shortest video is likely to change shape several times while you're planning it). The best way to keep on top of those changes is to enter them directly into your outline, not to scribble them on scraps of paper. More (and tools like it) allows you to move and duplicate blocks, change the level of an existing entry, and modify the outline numbering scheme to your liking.

No matter how you create your outline, once you have it stored in a computer, you can print it and use it as a guide while you shoot. Print the section that applies to the scene you'll be shooting next and carry it with you on a clipboard. As you tend to each element of the scene, check it off and make notes for those things you had to change on the scene. When you're finished, merge key notes back into the computer outline.

All this may seem fastidious, but using a computer to keep track of your plan and how it's carried out will be of immense help to you when it comes time to edit. A 5-minute videotape can require up to 50 or more minutes of raw video. Sifting through all that material can be overwhelming, but it's not so tedious if you've got the outline to help you.

Scene-by-Scene Planning

The lowest level of detail for your plan is a scene, and it's here that you need to invest the most time. Think about where to shoot each scene, how to prepare the room, who will speak, and what they'll say—try not to leave any detail to chance. Forget about technical issues like lighting and sound for now. Just imagine the scene playing out in your mind.

Composing a bit in advance can save you much time later. Go to the room where you plan to shoot a scene and bring your camcorder. Imagine where your subject will be and where you'll stand. Try to find a couple of workable angles in case you need to switch on the day of the shoot or you want to spice things up by shooting parts of the scene from different points of view.

Pay attention to what's behind your subject and avoid clutter. If you can't avoid it, try to put as much distance as possible between the subject and the cluttered background. The farther away the background is, the more out of focus it will be, and the less it will be able to distract the audience.

Another way to lessen the impact of the background is to

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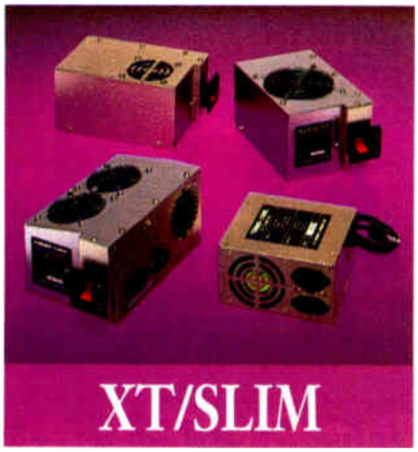

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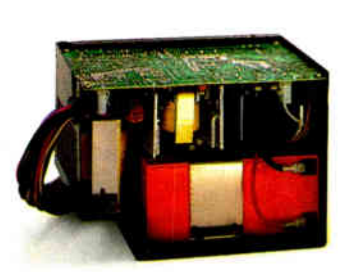

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Photo 2: *Shoot some of your video with graphical overlays in mind. Here, the video in the window was shot with the subject in a position and at a distance appropriate for this graphic.*

cover it with background paper, which is commonly used in still photography. The disadvantage of this technique is that it makes the scene look sterile.

Another trick involves lighting the background with a color slightly different from what you use for your main subject—using a colored bulb or a transparent filter, or *gel*. If your video camera doesn't do backlight compensation (or you just don't want to get into trouble), avoid shooting a subject who is in front of a brightly lit object, such as a window. Also, if your shot will include a video monitor or TV, be aware that those screens may flicker annoyingly on the recorded tape.

If your video depends heavily on dialogue, consider what will be said. In many cases, you can leave that up to the people who will be speaking, but offer guidance based on your vision of the project's intent. If the speakers have time to memorize their scripts, you'll gain the freedom to shoot from any angle, in any surroundings, without making room for papers and a flat surface.

If you're stuck, you can go all out and use a teleprompter (a computer that scrolls large text up a screen) or create cue cards. But these things will take a speaker's eyes away from the camera.

If a speaker can't memorize a whole speech, break it up and shoot it in pieces. Just remember when you stop to change camera angles before you start again. Leaving the camera in place produces an unnatural (and sometimes comical) jerking motion. You can correct this in editing, however.

Go Ahead and Shoot

Embed speaking script, special shooting considerations, and other notes into the scene detail of your outline. Plan ahead so that your outline can become a printed checklist. Make sure each scene has some unique identifier associated with it. Segment II, sequence 4, scene A might become scene II-4-A. You can also assign scene names or arbitrary scene numbers.

How you identify a scene isn't important; *that* you identify it is crucial. Buy a cheap erasable memo pad and pen and write the scene ID on it. Record 20 to 30 seconds of this marker prior to each new scene so you can identify scenes during the editing session even when you are fast-forwarding or rewinding. You could use the camcorder's tape counter, but this is inaccurate and resets when you change tapes.

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If you have a specific amount of time to fill, you may need to determine a target duration for each scene. If you have advance access to the script, read through scripted portions aloud and time them. You can budget time for shots that don't include dialogue; just time the shot as you shoot it. The danger in not planning is that you may end up with more of a gap between your target duration and what you've shot than even the most adept editing magic can cure.

When it's time to shoot, arrive early enough to run through your scene notes, rearrange the room if necessary, and discuss any last-minute changes with those involved. If you're using portable equipment, make sure you have enough charged batteries for the entire shoot. Pack plenty of blank tape. If you're shooting for anything but practice, *always* use new tape.

The Light Touch

As for lighting and sound, don't get too worried about them. The light sensitivity of modern camcorders often allows you to shoot in ordinary room light. But don't push it. Even though newer cameras boast the ability to shoot in light as dim as 1 to 3 lux, video shot at the lower end of a camcorder's sensitivity range often has muted colors and a grainy appearance.

Lighting problems usually arise when either there is too little light or the light is in the wrong place. If you're shooting in an office, for example, and the only light in the room is a desk lamp, you're in trouble. Similarly, if the lighting is bright and overhead, it may cast vertical shadows that deform whatever you're shooting. Fluorescent office lighting may cast a pallor on everything, but the light scatters evenly without a lot of shadows.

I use inexpensive clamp lights with white plastic reflectors and low-wattage bulbs. You can use them to illuminate an underlit scene or to compensate for shadows. The advantage of modern camcorders is that you can light a scene conservatively. If your subject appears too brightly lit to your eyes, it will likely record that way as well.

The number, type, and placement of lights you use are mostly matters of taste, but there are a few don'ts: Don't light people from high or low sharp angles, don't place the lights so they shine directly in a subject's eyes (as with camera-mounted video lights), and don't allow lights to be seen by the camera. Any good book on photography can help with lighting technique.

Once you've figured out how to light your scene, you should *white-balance* your camera: Adjust the camera for the color of the lights you're using. Simply aim the camera at any white surface (it's convenient to have a white mat board or something similar for this purpose) and push the white-balance button. To be most effective, you should place the board where your subject will be, especially if you have different kinds of light in the scene.

Capturing Sound Simply

Sound, like lighting, doesn't take a rocket scientist to manage. If you're shooting a person speaking, the camera-mounted microphone should be used only when you're in a hurry or shooting with a Steadicam JR. On-camera microphones frequently pick up zoom and auto-focus motor noises, and every time you touch the camera, it adds booms and snaps to your audio.

If you're shooting one person, have that person wear a small microphone and plug it into the microphone jack on your camcorder. If you're shooting more than one person, you can either give them individual microphones and use a mixer to combine the signals or use one or more table or floor-standing microphones.

Some situations defy simple approaches to sound recording. For this reason, it's important to play back the scene after you record it (but before you dismiss the players), listening to the audio through headphones. You can correct minor variances in

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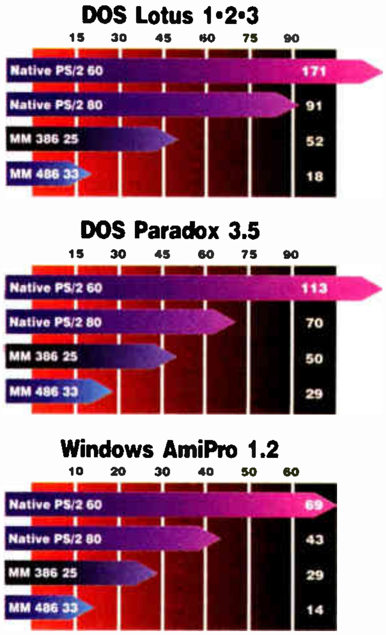

Benchmarks shown in these charts are based on real world applications, taking into account CPU, memory, disk, and video performance. Smaller numbers indicate higher performance.

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volume later, but you can't inexpensively fix distortion, background noise, or echo. If you hear any of these problems and can't figure out how to fix them, you'll probably have to shoot elsewhere.

Finally, if you plan to shoot a speech or some function that has its own sound system, tap into it rather than recording the sound in the room. It may sound fine to your ears, but sound from loudspeakers doesn't record well.

You don't have to spend a fortune on equipment to record audio. A couple of lapel microphones with long cords (good battery-driven electret models cost about $30), an assortment of patch cables, an audio mixer, and a set of audio adapter plugs are a good start.

Photo 3: *Film-to-video conversion devices, like this Tamron Fotovix III, turn slides and negatives into video. This unit doubles as a stationary general-purpose video camera.*

Laws of Composition

Some basic laws of composition apply to video, but they leave plenty of room for creativity. No scene should last less than 5 seconds unless you're shooting for effect. Shoot with later editing in mind; don't try too hard to do in-camera edits. Your camcorder doesn't always respond instantly to start and stop commands, so it's best to leave some free tape on both ends of every scene to make editing a little easier.

Go easy on all camera motion. Zooms and pans are hard on the eyes, and you should never do either of them frequently or quickly. It's often better to pause the camera, zoom or pan, and then start recording again; you'll get a clean cut that won't tax your audience.

You shouldn't always trust your camcorder's auto-focus. If you get creative, for example, and place your main subject anywhere but in the center of the frame, you'll confuse most autofocus systems. Other odd situations—like shooting through glass, low-contrast subjects, and patterns of horizontal lines—can also make auto-focusing slow or completely ineffective.

Most camcorders let you switch to manual focusing. Alternatively, you can place the subject in the center of the frame, wait until the camera focuses, and press the AF lock button to lock that focus setting. You can then reframe your subject wherever you like and keep it sharply focused.

If you or your subject moves while your camcorder is running, remember that whenever the distance between the subject and the lens changes, your camcorder must refocus. The A1 Digital's auto-focus can track a moving subject. That's not a common feature, however, and some camcorders' auto-focus systems are just plain inadequate. You might consider practicing manual focus, particularly if you intend to shoot a lot of moving subjects.

In addition to these laws, there are a couple of tricks to remember. Grab detail shots when you finish shooting the main scene. Interspersing some of these shots in your video will cure the monotony of the single camera angle and reinforce a speaker's words with footage that illustrates them. In my video, for example, I included a scene in which a member of the BYTE Lab talks about testing video monitors. I shot two scenes: First, I grabbed an interviewlike straight shot of the person describing the process. Then I shot a separate scene of the tests running. When I edit this scene, I'll alternate between the two shots.

You can simulate a two-camera shoot with a similar method. If you want to show the interviewer, for instance, after the interview is over, shoot the interviewer over the shoulder of the person being interviewed. The interviewer can be asking a question or just looking interested.

Variations on a Theme

These tricks might seem like common sense, but they actually take some getting used to. They are based on a couple of simple truths related to video production. To begin with, you don't need to shoot your video in any particular order. The editing you do later will let you change the order of what you've shot and trim out unwanted bits.

Don't stop and rewind to record over gaffes. Just leave the tape running, scribble *take 2* or whatever on the bottom of your scene marker, record a few seconds of the new marker, and keep going. Tape usually costs less than people's time, and if all else fails, you may get what you need from editing together the clean portions of the bad material.

The other simple truth is that video and audio can be edited separately. What makes the approach that's described above (i.e., my taping of the monitor-testing sequence) work is that when it comes time to edit, the video of the test in progress will replace portions of the interview without affecting the audio.

In the simulated two-camera shoot, there are times when you'll want the interviewer to appear to be listening to the interviewee's response—again, you'll insert only the video of the interviewer, leaving the audio alone. For the scenes when the interviewer speaks, you'll insert both audio and video. For each edit you make, you can choose whether audio, video, or both are recorded, and you can change either one at any time without affecting the other.

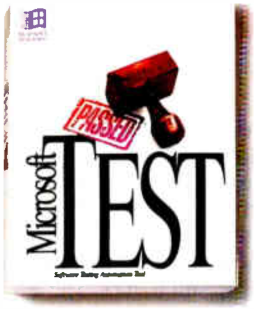
A last bit of advice I'll offer about setting up for a video shoot is to keep graphics in mind. For example, if you're shooting a speaker, and you plan to overlay the person's name during the editing process, be sure to leave room for that.

Consider other opportunities to mix computer-generated graphics with your scene as well. Any video scene can be overlaid with graphics. Although it's possible to size and position a video within a graphic during editing, the equipment to do this can be expensive, and it's not part of the Multimedia Lab's configuration. If you know you'll be shooting a graphic with a live video insert (see photo 2), shoot some video that places the subject at a size and position appropriate for the graphic overlay.

Be Still, My Video

When you're creating a video, it helps to have as much of your material in video form as possible. You can sometimes edit computer graphics directly into a production (more on that next month), but you can also record other still images to tape and edit them with everything else.

Without getting a computer involved, there are a couple ways to turn still images into video. For my "Inside the BYTE Lab" video, I needed to shoot several magazine covers, articles, and other printed matter. There was nothing glamorous about how I



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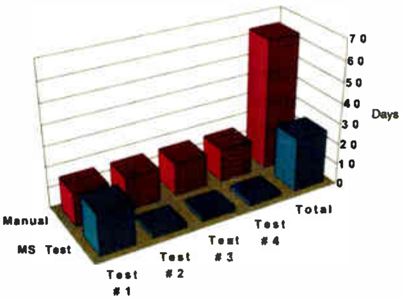

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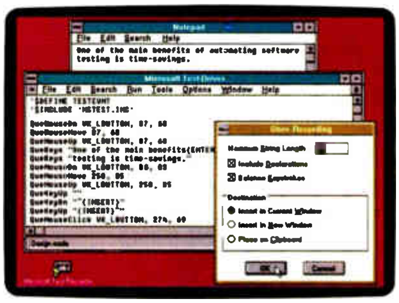

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- Recorder for keystrokes and mouse movements creates editable TestBasic test scripts easily.
- High-level English-like functions help users create test scripts quickly.
- Fast, exact comparisons between actual and expected results verify application quality.
- Screen capture and compare functions provide additional test results to verify application functionality.
- No hooks or debugging code needed, so Microsoft Test can be used with the final version of almost any application for Windows, no matter what development tool was used to create the application.

PROGRAMMER'S TIP

As an alternative to using Basic script language, call the Microsoft Test API with your favorite language, such as Microsoft Visual Basic™ or Microsoft C. Included in the product are .H and .LIB files for linking the TestCtrl, TestDlgs, TestScrn and TestEvnt functions into your C program.

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did it: Most tripods will let you point the camera directly at the ground. I set the material on the floor, added a few lights, and shot it. If what you're shooting doesn't fill the frame, you should put some colored paper (white is OK) underneath it.

The A1 Digital's freeze capability lets you use it like a video still camera. With its high-speed shutter (a feature it shares with many camcorders), you can record very sharp still frames. The advantage of using the same camera for all your video (still and moving) is consistency: The color and overall video quality will be the same.

If you have photographs or slides to include in your video, there is a better way to shoot them than on the floor or projected onto a screen. A number of film-to-video transfer devices (e.g., the Tamron Fotovix III in photo 3) make quick work of creating video from negatives and slides.

The Fotovix is really a video camera with a macro lens pointed at a backlit stage. It includes plastic carriers for negative strips and 35mm slides. This model has a zoom lens for cropping and controls for color correction and exposure.

The Tape's Run Out

There is a lot more I could say about shooting video for desktop video production, but the time has come to move on. Good video takes planning, and practice always helps, but almost anyone can shoot it.

Don't be afraid to flex your creative muscles. But always hedge your bet with a more conservative shot that can fill in if your experiment doesn't work. ■

Tom Yager is the director of BYTE's Multimedia Lab. He can be reached on BIX as "tyager" and on Internet at tyager@byteph.byte.com.

COMPANY INFORMATION

Canon U.S.A., Inc.
(A1 Digital camcorder, Xapshot video still camera)
1 Canon Plaza
Lake Success, NY 11042
(800) 848-4123
(516) 488-6700
fax: (516) 488-3623
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Cinema Products Corp.
(Steadicam JR camcorder stabilizer)
211 South La Cienega Blvd.
Los Angeles, CA 90016
(213) 836-7991
fax: (310) 836-9512
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Sony Corp. of America Business and Professional Group
(Mavica video still camera, EVO-9100 camcorder)
3 Paragon Dr.
Montvale, NJ 07645
(800) 523-7669
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Symantec Corp.
(More Macintosh outline-processing software)
10201 Torre Ave.
Cupertino, CA 95104
(408) 253-9600
fax: (408) 253-4092
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Tamron
(Fotovix film-to-video converter)
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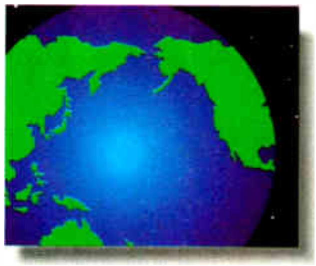


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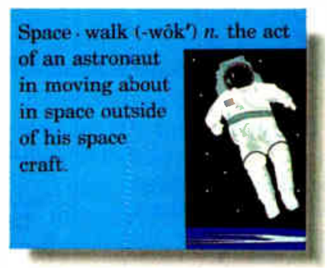

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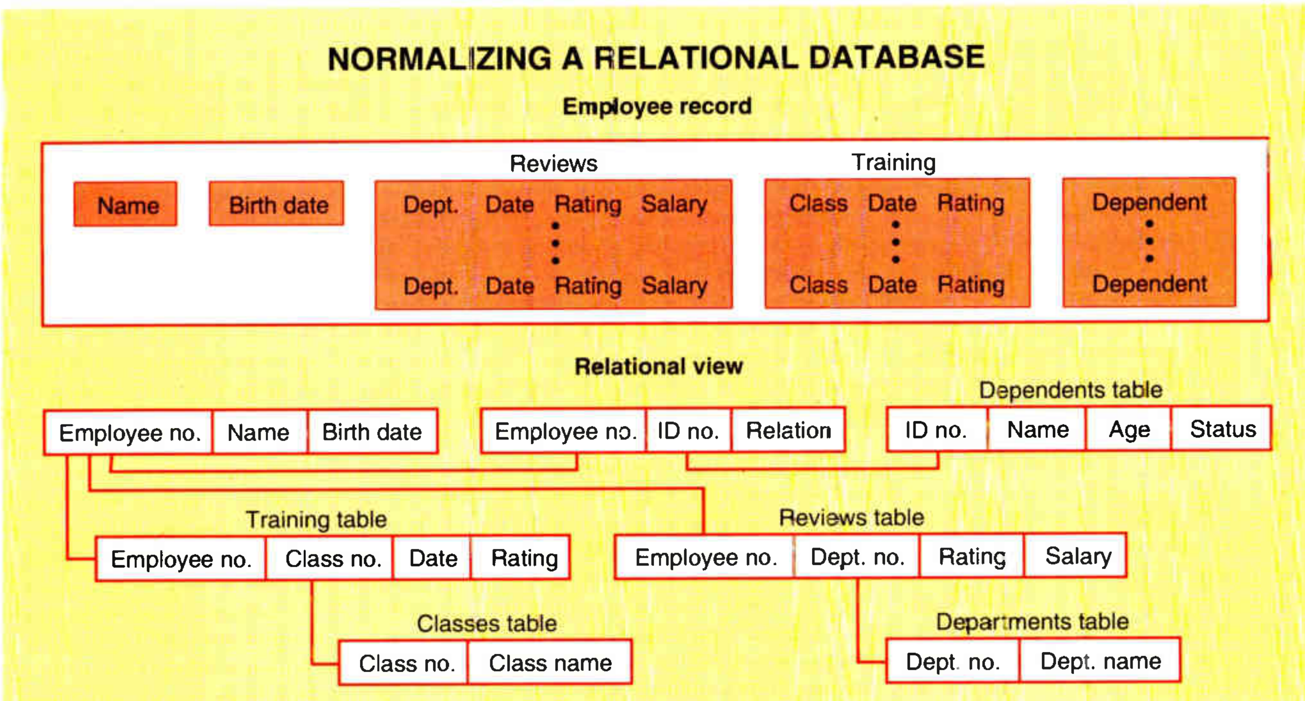


The process of normalizing a seemingly simple set of data can quickly lead to a labyrinth of key fields and join tables.

applications? There are three underlying issues:

- dealing with variable-length and variable-occurrence fields and groups in records;
- handling relationships among tables and files; and
- reflecting the true semantic content of the real-world structures that the database is intended to model.

Variability in the Real World

Some families have no children; some have many. Manhattan residents tend not to own cars, yet in Los Angeles, people often have several. Variability and repetition are constants in the real world. Programmers spend much time designing systems to handle such variations in a flexible but efficient fashion.

Early database designs provided elaborate mechanisms for representing variable-length fields and letting fields and groups occur once, many times, or not at all. The Pick database system owes much of its popularity to this fact—each field and group of fields in a Pick database record can occur as many or as few times as necessary. Associated programs accessing the data are insulated from this variability, and the database ensures that the records are stored in a space-efficient way that allows for rapid retrieval.

A key tenet of the relational model is to eliminate repeating fields and groups through a process called *normalization*. While normalization is a simple process, the result often involves mapping single files onto dozens of relational tables. The result is both hard to understand and inefficient to process (see the figure)

BYTE ACTION SUMMARY

Relational databases don't provide a sufficiently rich model of the real world and will likely be replaced over the next 10 years. The model most likely to push the relational model aside will be one similar to the old network model.

Relational Databases and Relationships

Most users believe that the word *relational* in the name *relational databases* refers to some ability to quickly build relationships between tables. I've often heard people describe the advantage of relational technology in terms of its ability to relate arbitrary tables to each other. Ironically, the thing that relational databases do least well is the handling of intertable relationships.

Relational databases are based on the theory of relations—a mathematical theory that deals with sets of tuples. You can think of a tuple as a row in a table. In relational theory, the set of rows contained in a table expresses a relation. To be mathematically pure, the rows must be intrinsically unordered.

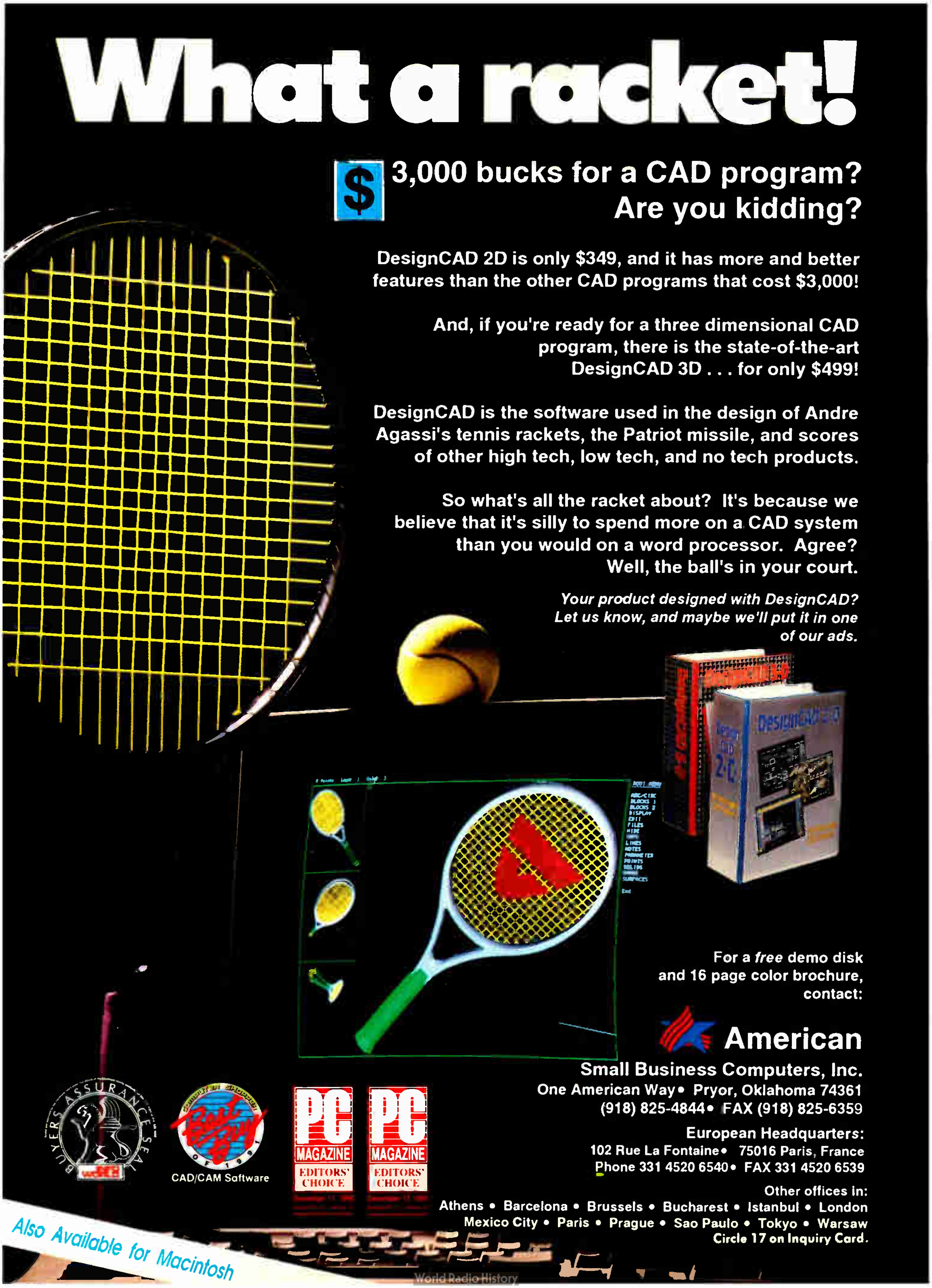
Thinking about the implications of unordered rows shows how far-removed true relational theory is from people's perceptions of it. Sorting and ordered retrieval are central to the way most people, particularly end users, think about their data. They think of databases as representing ordered sequences of records.

To put this in perspective, consider the most popular personal computer database in the world: Lotus 1-2-3. There are two reasons why you can use Lotus 1-2-3 as a reasonable database. First, personal computers can now have enough memory to support hundreds and thousands of rows. Second, sorting all the rows is easy to specify and incredibly fast to execute.

The ability to view spreadsheet rows in sorted order makes up for the lack of indexing and query capability. Now, imagine telling people that, to be relationally pure, they must never sort their data and that they can't assume the records are in any particular order. So much for the theory of relations.

But what about handling relationships in relational databases?

continued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Decision Support: Good or Bad?

Early databases, particularly those built around the hierarchical or network model, were designed to support transaction-processing needs. Later, relational databases were designed to support analytic applications, and they often fell into the decision-support category.

For two decades now, people have assumed that the ideal environment would be one in which the same database used to support an organization's transaction processing would drive the analytic applications. The fact that these databases have been separate and parallel has been seen as a necessary evil. Having a separate analytic database makes a lot of sense, and, when properly designed, the parallel database is a mark of an organization's maturity in defining its analytic requirements.

On Time, Within Specification

Transaction-processing databases deal with data that must be up-to-date. Individual transactions depend on all previous transactions being completely recorded so you truly have an up-to-date picture of the data you're examining. Transaction-processing databases typically retain only small amounts of history, and individual transactions deal with relatively small amounts of data. Usually, however, many of these small transactions are running simultaneously.

In an analytic database, dealing with up-to-the-minute data is a prescription for failure. You must often run what-if scenarios several times, with key variables changing in value. If the underlying database reports instantaneously accurate data, the analytic user would need to either lock the entire database throughout his or her analysis (a period of days or weeks) or deal with a constantly changing data world.

The classical solution to this problem is the creation of accounting or analytic periods. Thus, most marketing analysis is done in months or quarters, and having data that is accurate to the end of the last month or quarter is usually more than adequate.

Even in an extreme case, when you are looking at data across an entire organization, having data that ends the previous day or week will virtually always be adequate for analytic applications. However, it would be totally inappropriate for transactions.

Analytic applications work with large amounts of historical data. Marketing analyses frequently compare this year's data with last year's, or this quarter's data with comparable quarters for the past several years, looking for trends. Working with such vast amounts of data implies large applications runs, examining hundreds or thousands of records.

Yet even in a big organization, only a limited number of people will launch these applications at any one time. So the picture is one of large numbers of records and massive amounts of historical data being manipulated by a small number of users. This is the exact opposite, again, of the transactional environment.

The Same, Only Different

What about the underlying data itself? Is it the same or different in the two environments? Transactional data is quite detailed. Individual line items in an order, specific transfers from one account to another, and particular items picked out of inventory and placed onto specific pallets all define transactions.

Analytic data consists of summaries and aggregates; the crossing of individual transaction boundaries; and representations of product lines, geographical areas, and organizational entities. For example, analytic entries might deal with all the products sold in a store in an entire day or ending inventory levels for each warehouse by month, by product line, and so on. While you can derive these aggregates from the transactional data on demand, it would be prohibitively expensive to do so.

Analytic data is different in a more fundamental way, too. The design of transactional databases is based on so-

The fundamental mechanism for establishing relationships is the join. There are three fundamental problems when you start dealing with relationships. First, most people don't understand what a join is. Furthermore, because relational databases should be normalized, dealing with real-world views often requires numerous joins. Trying to explain to nontechnical people how to join 15 or 20 tables to provide an intuitively obvious view of the data is basically impossible. And often, when a join is constructed, the resulting view runs inefficiently—in other words, slowly.

Second, by definition, joins are temporary. The very strength of the relational approach, breaking complex records into simple tables, is also its biggest weakness. You should not have to figure out the relationships between parts of the database; the database designer should be able to build them into the structure of the database. However, to do this would essentially mean converting a relational database back into a network database.

Finally, relationships are always associated with integrity constraints and other business rules: for example, don't delete customer records that contain outstanding orders, and don't charge goods against nonexistent credit cards. However, with no method of expressing interfile relationships in the first place, these business rules cannot become a built-in part of the database.

Historically, this last problem has meant building all the business rules into applications code. More recently, some relational databases have let the data dictionary store business rules as "stored procedures" written in Structured Query Language and executed whenever you made changes to the database. However, this approach still falls short. The simplest way would be to tie integrity constraints directly to database relationships.

Semantic Modeling

The dictionary defines *semantic* as "relating to meaning." Therefore, a semantic model describes the meaning, as opposed to the superficial form, of a database or application. When building any large application, a key prerequisite is a comprehensive definition of the requirements, followed by a thorough design prophisticated data-modeling techniques that let the files and records in the database model the real-world entities and relationships of the organization.

Historically, however, analytic databases have been designed in a much more ad hoc fashion: extracting data from the transactional environment, applying some simple aggregations, and leaving it at that. As it turns out, this process doesn't come close to meeting people's needs once they move past their first few decision-support systems. And when the same sophisticated data-modeling techniques are applied to the analytic environment, the underlying structure of the database turns out to be quite different from the structure of the transaction-processing systems.

For example, price changes are always tricky to handle in an analytic system. In one case, a marketer ran a promotion and, after analyzing the data, found that it increased sales by 10 percent in a one-month period—an incredible result—until further analysis found that the entire increase was accounted for by a price increase that was happening at the same time. A well-designed analytic database would automatically account for any price changes.

In another case, a manufacturer was analyzing change patterns in its channels of distribution. It appeared that sales to distributors were increasing substantially. However, further analysis showed that a change in discount levels made it possible for distributors to buy a product and resell it to the manufacturer's largest national chain at a lower price than what the chain paid to buy the product from the manufacturer. An analytic database should automatically sort out these kinds of cross-channel transfers, or at least highlight them without being told.

Finally, in a large sales organization, one part of the organization has a monthly reporting period that begins on the twenty-fifth of the month, while another's reporting period begins on the first of the month. An analytic database would automatically correct for disparate reporting periods.

How real are these problems? Every large organization has stories about different people—usually senior executives—asking for reports dealing with the same question and receiving widely disparate answers. The punch line is that when it comes to real decision making, you can't trust computers. Therefore, designing an analytic database that provides meaningful answers is hard to do but worth the effort.

Coming Full Circle

What should an analytic database look like? It should be derived from the transactional data (i.e., the transactions should provide the data). It should be a tabular database, similar at some levels to the relational model. The data should be composed of various aggregates, summaries, and specific derived measures of performance organized into a time series.

A variety of complex mechanisms should provide for hierarchical consolidation by product line, organizational entity, and customer organization. And the actual data structures, while tabular, are not relational in the classic sense of the word.

Rather than having hundreds of hard-to-understand normalized tables, the view of the data should be of a relatively small number of large, highly denormalized tables that provide several orthogonal views of a company. Typically, views should be by product, organization, and customer.

Analytically oriented databases today are separate and parallel to transaction-processing databases out of necessity. However, this is a good point, rather than a bad one. Analytic databases generally need considerable improvement to be truly useful. The improvements, however, will push them farther from their transactional roots rather than closer. The end result, however, will be two in-depth views of how a company operates: one modeled along transactional lines and one modeled along analytic lines.

cess. During this analysis and design, most structured approaches build a semantically based data model. While many different approaches to data modeling are in use, most of them ultimately depend on some form of entity-relationship structuring.

Ironically, an entity-relationship model looks much like the schema for a network database. Even more ironic is that after building a sophisticated entity-relationship model that shows all the links between the records and expresses all the integrity constraints and business rules, you strip all this definition out of the model to express it in the form of relational-database schemata.

What About Object-Oriented Databases?

Over the past few years, a new style of database has gained some popularity: object-oriented databases. A key attraction of OODs is that they can work directly with complex data structures that relational databases cannot conveniently handle. OODs let records contain variable-occurrence and variable-length items. Building on the flexibility of the record structures, OODs can represent interfile relationships directly in the database structure.

At one level, OODs offer a convenient solution to the limitations of relational technology. Yet they have problems, too. For one, OODs are still experimental. They require the use of an object-oriented language such as C++ or Smalltalk and often run only on Unix-based workstations with large amounts of memory.

Also, query tools and report writers for OODs are quite limited in scope. Most research in ad hoc end-user tools over the last 10 years has focused on relational databases. As a result, there are few tools that work well in the more complex world of network-database structures.

Finally, OODs are well suited to relatively small collections of complex records (e.g., in CAD and CAE applications, where OODs can be 10 to 100 times as fast as comparable relational databases). Faced with larger collections of relatively simple records, OODs are slow and lack adequate reliability mechanisms. While they point to the future, OODs are not an answer to the limitations of relational databases today.

continued

Back to the Future

It is not clear today how database technology will evolve to meet the needs of tomorrow's users. However, the answer is likely to come from two basic trends, which are described below.

Data modeling. As more organizations commit to CASE technology to facilitate analysis and design, database vendors will increasingly look for ways to link CASE tools directly to the underlying subject databases. The entity-relationship diagram and the database schema should eventually be the same object. This step alone, when it occurs, will create postrelational databases.

Data-modeling technology is evolving, too. The next major step is to incorporate object-oriented analysis techniques directly into the data model. Several leading practitioners already teach this approach. The result is a richer data model that deals with entities (now called *objects*), relationships, and methods, all at the same time. From there, it will be only a small step to have this data model also be the same as the database model.

Object-oriented databases. Relational database vendors perceive themselves, correctly, as being under attack by the OOD vendors. They have a sense of déjà vu, as they remember the days when the leading nonrelational vendors owned the market, only to be displaced. Naturally, the relational vendors are determined to not let history repeat itself. As they develop approaches to incorporate the benefits of the OODs into their relational products, the resulting product evolution is bound to see a closer mapping to the real world.

Returning Home

In the 1980s, analytically oriented end users were so happy to have any access to data that the simple relational approach, with its focus on easy-to-understand tables, rows, and columns, more than met their needs. They benefited from the ultimate relational database of the 1980s: the personal computer spreadsheet. With its ability to sort thousands of rows in seconds, express complex calculations trivially, and propagate the effects of changes through dozens of related rows and columns quickly, they were free to push the table approach to its limits.

In the 1990s, these same people are starting to deal with more complex sets of data. Relationships between tables are becoming commonplace topics of discussion. And, since manipulating individual tables is now so trivial, these people want to be able to create more and different tables quickly and easily. Creating new tables means navigating through sets of files to arrive at new and particular combinations of data elements.

Ironically, the classic solution to this problem involves denormalized databases. First, you build pure, fully normalized databases. You find that people can't deal with the resulting proliferation of tables. Then, as a good analyst, you spend months determining what views of the world people really want. And, when you're done, you express these views in the form of highly denormalized tables that represent the joining of many simpler tables. Not only is the result not relational, it's not efficient, and it's certainly not elegant.

Coming full circle, the original transaction-processing applications, which needed richer database structures in the first place, still do. The analytically oriented end-user applications need those richer structures, too. Relational databases still make sense for many kinds of applications that lend themselves to expression as simple sets of simple tables. However, to build applications that reflect the real world, you will have to find a way to take another two steps forward—this time to a postrelational world. ■

David Vaskevitch is director of Strategic Services for Microsoft Consulting Services at Microsoft (Redmond, WA). You can contact him on BIX c/o "editors."

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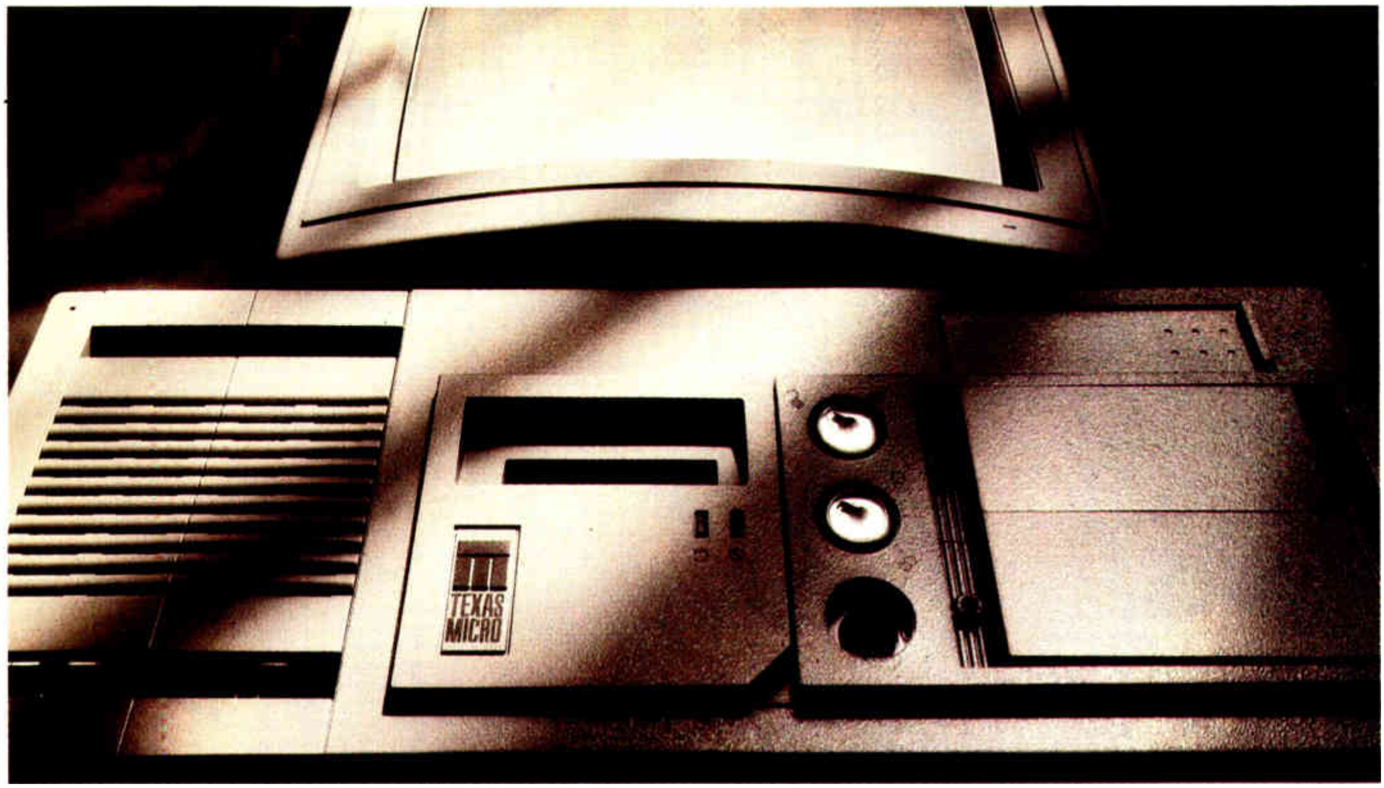

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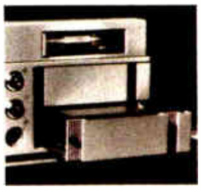

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ROOTS AND BRANCHES OF 3-D

3-D graphics are adding to the ways you can view the world through computers

JIM CLARK

Computer graphics is almost 30 years old, and it has finally become an integral part of virtually all computing, from visualizing spreadsheet graphs to seeing the three-dimensional flow fields of computational fluid dynamics. Most of the growth has occurred in the last 10 years, with the development of the workstation and personal computer industries. In the coming decade, many new 3-D applications will be developed for graphics, and by the year 2000, consumer devices will routinely have 3-D realistic graphics capability. This article looks at the important milestones of computer graphics and projects a future where 3-D graphics is totally integrated into our lives.

Early Graphics History

Computer graphics began in the early 1960s at MIT. While in the doctoral program there, Ivan Sutherland wrote a series of interactive-graphics programs on a TX-2 computer, which had a vector-drawing CRT display connected to it. *TX-2* stands for Transistor Experiment 2. It was the first transistorized computer, and because it had a dedicated graphical display, it was also the first workstation. Sutherland's programs relied on the computer to do all the graphics calculations because it had no graphics accelerator. His thesis, called "Sketchpad," developed a wide variety of concepts, including object-oriented programming, constraint-based visual computing, and real-time interactive programming. But "Sketchpad" was a 2-D system; 3-D required too many calculations for the TX-2.

After leaving MIT and a brief stint as director of information processing for the Department of Defense's Advanced Research Projects Agency, Sutherland joined the Harvard faculty. One of his doctoral students, Danny Cohen, was interested in flight simulation. Working with industry support, Cohen developed the first 3-D flight simulator—a vector-drawing system. At Harvard, Sutherland and Cohen developed the first head-mounted display, which had a mechanical position sensor. It allowed you to walk about in a small virtual world, seeing wireframe virtual images that floated in front of you. Cohen worked out the mathematics and developed the software for this project.

At about the same time (around 1968), Sutherland met Dave Evans, who had just left the University of California at Berkeley to become the head of the computer science department at the University of Utah. One of Evans's students had written algorithms to render static shaded pictures of 3-D mathematical objects. Sutherland was stimulated by the possibilities of real-time shaded-image generation. As a result, Evans was able to persuade Sutherland to leave Harvard and join the Utah faculty. During the next few years, the roots of 3-D graphics developed.

Two Branches of 3-D

Two branches of 3-D computer graphics evolved in the work done at the University of Utah. The first is ultrahigh-quality rendering, which I'll call *photo-realism graphics*, and the second is *real-time graphics*.

Photo-realism graphics focuses on the realism of a computer-generated picture, with little concern for the time required to compute it. In real-time graphics, interaction and speed of rendering are the foremost concerns. The rendering

speed must be at least 10 frames per second, and quality is attained by adding hardware capability.

Photo-Realism Emerges

In the early days of photo-realistic computer graphics, shaded-picture algorithms used polygons to crudely model every object, smooth or not. In those days, because computers were very slow, the computations were focused primarily on solving the so-called hidden-surface problem. Flat, polygonal objects have simple geometries, so they require the least amount of computer time to determine which surface is in front of the other. Even though the quality of the renderings from the first algorithms were better than that of wireframe line drawings with hidden lines removed, they could hardly be called photo-realistic graphics.

In 1974, Ed Catmull started the movement toward photo-realism at the University of Utah. He was the first to make pictures of smooth surfaces. Previously, Henry Gouraud and Bui Tong Phong had used smooth-shading tricks to make the eye see smooth objects modeled as polygonal surfaces (see "Photo-Realism" on page 167). Catmull decided to use mathematically smooth surfaces called *bicubic surface patches* to model objects that were supposed to be smooth, instead of trying to approximate them with a lot of polygons. The problem with this approach was that no analytic solution existed to render bicubic surface patches, so Catmull used *recursive subdivision* to approximate the surfaces, subdividing the bicubic surface patches until they were about the size of a pixel.

Catmull developed the concept of a z-buffer to solve the hidden-surface problem for each of these pixel-size surface fragments. The z-buffer now pervades all graphics. He invented alpha blending to simulate transparencies, and he invented texture mapping, a special method for mapping images onto geometry. A brick pattern, a digitized photograph, or another image can be mapped onto the geometric surface patches, increasing realism. Environment mapping, bump mapping, and other special effects are based on texture mapping. The images Catmull produced were the most startling ever seen.

Catmull left Utah after graduate school and formed the New York Institute of Technology's Computer Graphics Labs, which became dominated by the realism school of thought. Later, he founded Pixar.

Lighting and Modeling

In the early 1980s, Turner Whitted developed a rendering technique called *ray tracing*. Prior rendering algorithms had not considered the refraction and reflection effects of basic geometrical optics. Whitted showed that ray tracing effectively modeled light bent by a prism, and it could show objects reflected in other shiny objects. His pictures took hours to compute, but they perpetuated the trend toward realism.

A modeling method based on fractals was the next step in photo-realism. Coastlines, mountain ranges, and many other natural phenomena can be perfectly modeled by fractals. In 1980, Loren Carpenter stunned the graphics world at Siggraph with an animated film depicting a mountain range that was continuously refined with more and more detail as a virtual camera approached the mountain and flew over it.

The last big step in the emergence of photo-realism came in the mid-1980s from a group at Cornell University led by Don Greenberg. Borrowing the radiosity algorithm from radiative heat transfer engineering, they modeled the effects an environment has on lighting (see "Radiosity" on page 173). For example, as light shines on a wall, the wall radiates its color, which contributes illumination to nearby objects. Objects close to the wall also illuminate the wall with some of their color. This mutual-illumination effect requires the solution of a very large set of simultaneous equations—it's basically finite-element analysis applied to the diffuse effects of light. It was the most time-consuming rendering method invented, but its realistic effects were beautiful, especially for architectural interiors.

Coming of Age

The next major hurdle in photo-realism is to integrate ray tracing with an extended form of radiosity. Radiosity considers only the diffuse effects of light; reflections and directional aspects are ignored. In heat transfer, this is fine, but radiosity images always look a little flat because they have no reflective character—things that should shine look dull. Ray tracing, on the other hand, doesn't have the mutual illumination of radiosity. Combining them implies very lengthy and complex computations, but the result would cover all aspects of illumination. Photo-realism would then just depend on the nature of the modeled environment.

The emphasis on photo-realistic rendering algorithms comes from a desire to understand and computationally model the effects of light on virtual environments, but it hasn't always been just for the sake of realism. Photo-realistic rendering makes computer images exciting. For example, morphing was used to produce the special effects in *Terminator II* that created the liquid-metal man. But many methods used to convey information in scientific visualization techniques (e.g., mapping colors onto objects to represent temperature or pressure and using transparency effects to simulate thunderclouds) were developed in the pursuit of realism.

Critics of photo-realism, such as Gordon Bell and Bill Poduska, who insist that it isn't important for most scientific applications, miss the point. The main application of photo-realism is to deceive or illuminate in a new way, and it is essential in visual-simulation applications.

Photo-realistic algorithms are slow even on supercomputers, but they repeat certain computations many times. To speed them up, it's natural to try to accelerate these computations with specialized hardware. This can reduce the computation time by a factor of 1000 or more, potentially allowing real-time performance.

Real-Time Graphics

The difference between static photo-realistic graphics and dynamic real-time graphics is huge. Static images exist for their own sake, and they are equivalent to photographs of synthetic worlds. At best, they can be put in a recorded sequence (e.g., a movie) to achieve animation.

Real-time graphics, however, engages you in interaction with a computer that expands what you can do and how you can do it. With good interactive 3-D software, you can reduce to minutes what would take weeks of model building. Your interaction with realistic images enables otherwise impossible applications, such as virtual reality games and visual simulators for driving and flight training.

You can begin to understand things smaller and larger than life, from molecules to galaxies, and explore otherwise invisible worlds with real-time interaction. Visualizing the 3-D helical structure of DNA was essential to reaching an understanding

BYTE ACTION SUMMARY

Today, 3-D graphics offers new ways of visualizing information with computers. The 3-D technologies are found in virtually all applications of computers, and tomorrow, even consumer products will have photo-realistic 3-D graphics capabilities.

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3-D CAD Meets the Real World

STEVEN J. VAUGHAN-NICHOLS

Three-dimensional CAD is a wonderful idea. But what happens when the rubber of 3-D CAD meets the road of real-world jobs? The 3-D applications do just fine when put to the test of industrial design.

3-D CAD in Space

Greg Jones is the head of the CAD section in the mechanical engineering branch of NASA's Goddard Space Flight Center (GSFC). His branch uses Schlumberger's Bravo3 and Structural Dynamics Research's I-deas to make concept models of potential spacecraft and instrument configurations. These programs make it possible to "demonstrate the feasibility of a particular spacecraft concept," Jones says.

GSFC scientists come up with a plan for a spacecraft mission. After deciding what instruments they'd like to see on the platform, the proposal is turned over to Jones's section.

His group develops the first studies of the proposed satellite. At this stage, the prime question is whether all the components will fit properly in the satellite. Using 3-D CAD makes the process smoother. In Jones's opinion, a 3-D CAD user will take only one-half to one-third of the time required by an equally skilled 2-D AutoCAD user to produce the same results.

But 3-D CAD has more than just production speed going for it. Nontechnical personnel find 3-D solid images easier to understand. Even engineers without a mechanical engineering background find solids easier to grasp than wireframes—much less engineering drawings.

Jones goes on to say that "the real advantage of I-deas is its tight coupling with AutoCAD tools." I-deas works hand in glove with AutoCAD. Autodesk's Advanced Modeling Extension Link enables users to transfer AutoCAD/AME solid-modeling data to I-deas. In return, Structural Dynamics Research's Solid Link allows designers to transfer their files to AutoCAD. At Goddard, I-deas is used to develop a satellite or component in solid geometry. From there, the image is transformed into AutoCAD DXF files for reference-configuration drawings.

Jones prefers to work with applications that can run on several different platforms or, at the very least, exchange data across platforms. He is fond of I-deas and AutoCAD, which run on a variety of architectures and operating systems. "I-deas doesn't lock us into a particular platform," says Jones.

Another useful tool that meets the interoperability standard is MacNeal-Schwendler's MSC/Nastran finite-element-analysis software. This package, used with I-deas' finite-element-model builder, enables spacecraft designers to quickly answer such questions as whether a panel will be strong or stiff enough for a particular job.

It is not all sweetness and light at GSFC. The 3-D CAD programs are slow. Both Bravo3 on DEC VAXstation 3100s under VAX/VMS and I-deas on IBM RISC System/6000 workstations under AIX are only adequate in terms of speed.

Another problem is that 3-D CAD's learning curve is steep. "To get good at the 3-D programs takes a long time," Jones says.

It's time well spent, he believes. The speed, flexibility, and interoperability of 3-D CAD make satellite design a much faster and surer proposition than it has been in the past.

3-D CAD at Sea

David Garbeil is a senior manufacturing engineer at Westinghouse's marine division in Sunnyvale, California. He uses Autodesk's AutoCAD release 11 with Autodesk's multimedia presentation software, 3D Studio and Animator Pro, to work in mechanical product development.

Westinghouse employs an approach called *concurrent engineering*. "We design the assembly line at the same time that the product is designed," says Garbeil. The company avoids being stuck with products that existing assembly lines are ill-suited to manufacture.

Like Jones, Garbeil finds that using 3-D solid models is an excellent way of enabling nontechnical people to visualize complicated mechanical devices. Moreover, the assembly process can be demonstrated by taking a solid model and using Animator Pro to strip off the surface mesh so that the model can be used by 3D Studio.

The resulting animated graphics are useful for more than just an impressive display. By simulating a product's assembly and its operation, mechanical problems can be spotted and corrected long before a working model is made.

Once a product has been successfully crafted in computerized clay, the next step is to create its engineering drawings. Again, AME proves its usefulness. The solid models made in model space can easily be transformed into "paper space," a separate viewing and plotting environment from which engineering drawings are generated.

Garbeil agrees with Jones on the importance of interoperability. His shop runs AutoCAD on PCs and workstations. "A real advantage of the AutoCAD family is that it will run on many platforms and that data can be easily interchanged from system to system and from product to product," he notes.

Although AutoCAD is easy to learn, 3-D CAD is too complicated for 80 percent of the CAD jobs, Garbeil observes. For the remaining 20 percent, however, 3-D CAD is extremely helpful.

With multimedia and finite-element modeling, 3-D CAD is putting unimagined power into mechanical designers' hands. By enabling users to model reality more closely in their designs, 3-D CAD will sweep other design methods into the dustbin of history, in the same way CAD programs swept drafting tables into the antiques market.

Steven J. Vaughan-Nichols is a full-time freelance writer and former programmer/analyst from Lanham, Maryland. You can contact him on BIX as "sjvn."

The best C/C++ tools for Windows are from the company that makes Windows.

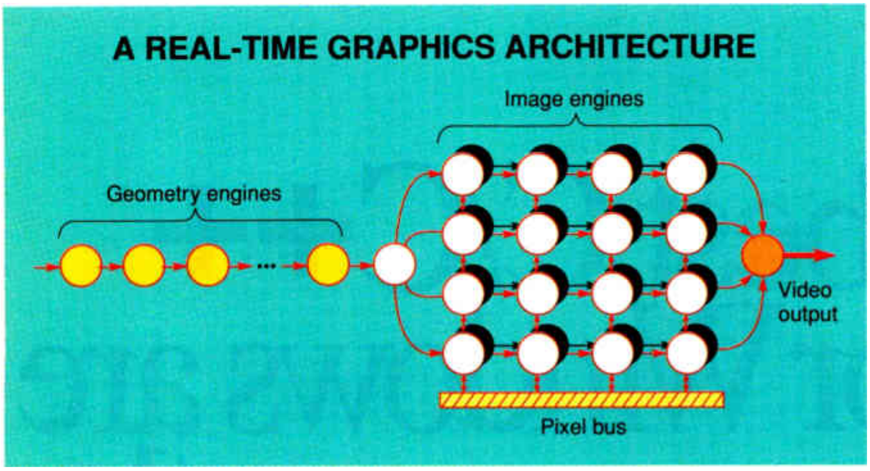

Figure 1: *The old design for real-time 3-D computing. The special-purpose geometry engines pass their output to the special-purpose image engines.*

of it, and interactive graphics will surely lead to discoveries in molecular biology and chemistry. Interactively manipulating images produced by 3-D CAT scans and magnetic resonance imaging enhances medical understanding. Some surgeons use real-time graphics to assist them in the operating room. With real-time 3-D graphics, you can move through a design as it's being developed. This technology is also being used in automotive and aerospace design (see the text box "3-D CAD Meets the Real World" on page 156) as well as in architecture and landscape design. Science, medicine, design, and technology all benefit from interactive visual computing.

3-D Programming Interfaces

Both photo-realistic and real-time graphics require a programming interface. (See the text box "A Programmer's Guide to Computer Graphics" on page 162.) Very little has been done to provide photo-realistic rendering packages, perhaps because of their specialized market uses. In commercially available systems for photo-realism, the interface is often buried inside the end-user package. But an external programming interface is needed if an application is to include rendering in its own environment and not cause an end user to have to run a new application. Pixar, for example, offers the interface specifications for RenderMan, and the rendering routines available from those specifications provide reasonable photo-realism quality.

The history of interactive-graphics packages is not very coherent. Before 1980, the only interactive-graphics interfaces were ACM Core and the graphical kernel system, as well as the Picture System II interface that ran on some products from Evans & Sutherland Computer Company. The PS/2 interface was the only one based on the working needs of a real-time user, so it was the only one, in my opinion, that was worthwhile. GKS was just a 2-D specification, and Core was crippled from the beginning because it was a committee-defined proposed standard that had everything in it, including the kitchen sink. In 1982, Silicon Graphics implemented Core and discovered that using it would require about four times more subroutine calls than would its Graphics Library (GL). Even worse, it was very hard to read programs written with it.

The GL is an adaptation of well-worn software that Martin Newell (who defined the famous teapot that is used as a benchmark for rendering) and I had used in teaching computer graphics classes. Its interactive character and structure is patterned after the PS/2's interface, which I had also used extensively in writing real-time graphics systems for NASA. Because the GL is based on working systems, and because of the large number of applications that have been written for it, it remains the best graphics interface that is available, despite its shortcomings.

For political reasons, and because the GL was proprietary for a number of years, PHIGS+ (programmer's hierarchical interactive graphics standard) was developed. A version of it called PeX (PHIGS plus X) combines PHIGS+ with the X Window System interface. PHIGS+ was defined by a committee that had little experience with real-time 3-D graphics, so it has more routines than is necessary. Because it was defined before workstations had replaced graphics terminals, much of the interface deals with arcane display-list issues.

Display lists used to be necessary in semi-intelligent terminals because their I/O was typically over low-bandwidth interfaces (e.g., RS-232) to a time-shared computer. The only way to get real-time performance over a low-bandwidth channel is to store most of the graphics data locally in an intelligent terminal. The semi-intelligence came from display-list processors. Before microprocessors, display-list processors were limited-instruction-set units designed by vendors of graphics terminals, usually based on the AMD 2900 family. Because they didn't have compilers, they were simple and needed constrained display lists of instructions.

With the advent of workstations and client-server computing, however, the functions of a graphics terminal could easily be had on a programmable workstation. The hierarchical data structures necessary in display-list processors could be replaced by display subroutines that called each other, forming an equivalent hierarchy. This required a notion called *immediate mode*: Drawing is initiated when a workstation processor sends graphics commands immediately to a graphics system as they are encountered rather than storing them in a display list.

In 1982, computer graphics developers recognized the simplicity of this approach, and they developed an immediate mode for all GL commands. Obtuse, hierarchical display lists were no longer necessary. PHIGS+ is now being extended to include an immediate mode, but it still has the historical baggage of display-list code, which might confuse a new user.

The GL is available to anyone for a very small license fee. Although politics enters into some companies' decisions to license the GL from Silicon Graphics, the community of 3-D applications developers will ultimately determine the preferred real-time graphics interface. So far, they have chosen the GL.

Real-Time 3-D Hardware

Because of its computational requirements, interactive graphics needs specialized hardware. Just as parts of the human nervous system are specialized for visualization, so must parts of the computer system be specialized. It's true that some RISC processors are adequate for the simplest interactive-graphics computations, but it will be many years before general-purpose computers can compute photo-realistic images in real time. Machines designed for the task will always be better.

Specialized high-performance graphics systems have been constructed in modest volumes for the last five years. All commercially available systems use, with minor variations, the data-flow architecture shown in figure 1. Henry Fuchs was the first to

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EXE size	5K	7.3K
Execution time	820 sec	1500 sec

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Using fast compile, pre-compiled headers	300 sec	420 sec
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Inline any C/C++ code	Y	N
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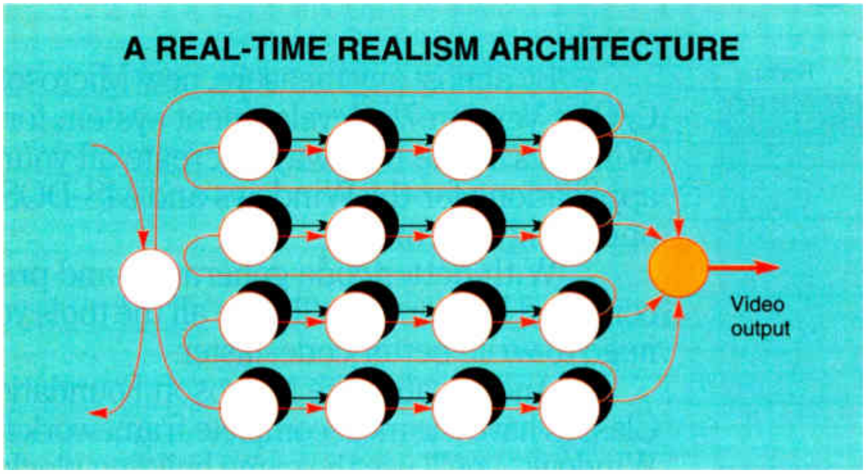


Figure 2: *The proposed new design for 3-D computing. The processors used for the geometry engines and the image engines are the same. They are general-purpose processors.*

suggest this rectangular pattern of image engines, but it needed a busing structure to make it work. I developed one such structure at Stanford in 1979 and suggested to my student Marc Hannah that he continue the architecture for his doctoral thesis. Our design wasn't exactly like that shown in figure 1. It didn't handle textures and images, but the basic design was workable and had simple connectivity. As I describe later, it's the variations that are now possible on this design that lead to important improvements for real-time 3-D.

In the simple design of figure 1, geometric data is fed to a system over a geometry input port. Geometry engines manipulate raw surface geometries with rotations, translations, shading, subdivision, and pixel sampling (i.e. determining where pixels intersect the geometry). This traditional design works like an assembly line, with each geometry engine doing a small piece of the work and passing it on to the next stage. This is called *pipelining*. Using faster geometry engines results in rendering more surfaces in real time. On the other hand, in low-cost systems (e.g., the Silicon Graphics Indigo and some of the Hewlett-Packard/Apollo workstations), the general-purpose RISC processor also does the graphics processing. These systems provide minimal performance.

Pixel and image data enter the system over a pixel bus. The imaging part of the system does all pixel processing (e.g., z-buffering, image accumulations, alpha blending, and texture mapping). Each image engine includes a pixel processor and screen memory.

An array of image engines processes the pixels in blocks. For example, 16 processors forming a 4-by-4 array would simultaneously process the first 4-by-4 block of pixels. The processor array would then work on the next 4-by-4 block of pixels and repeat this procedure until the screen was completed.

The interleaved pattern of 16 or more processor/memory modules is important for two reasons. First, low-cost DRAM is slow, and having a large number of tightly and uniformly interleaved memory modules increases the composite access bandwidth. Second, many pixel computations are required for real time. The more processors there are in a system, the faster it can compute an image.

In 1986, Silicon Graphics was the first to produce a commercial implementation of this old design. Today, however, the design is good only for processing triangles, lines, and characters. To approach real-time photo-realistic rendering, it must be modified. If the changes are general enough, arbitrary geometric primitives (e.g., surfaces, fuzzy objects, and generalized routines) and lighting effects (e.g., radiosity and ray tracing) will be possible.

A New Design

What I propose is a new design that could make realistic real-time graphics possible. First, it would be nice to use the same engine for both the geometry and the image processors. They should be generally programmable in a high-level language. A general-purpose RISC processor at each site could do geometry computations, and with a little acceleration for texture mapping, it could also do the image calculations. Second, all processors should be able to rapidly and easily communicate with each other. A suitable array structure with more general connectivity for geometry and image engines is shown in figure 2.

Each engine in this ring-bus structure has image memory, a RISC core processor, and suitable accelerators for texture mapping and image-memory access. Graphics computations can be distributed very nicely. For example, the old design in figure 1 can be overlaid onto the new design because of the ring's complete connectivity. As before, geometric computations are still distributed over the 16 engines in a pipeline fashion. In this new design, however, when the results of geometric computations are available, the same set of engines works on the pixel processing.

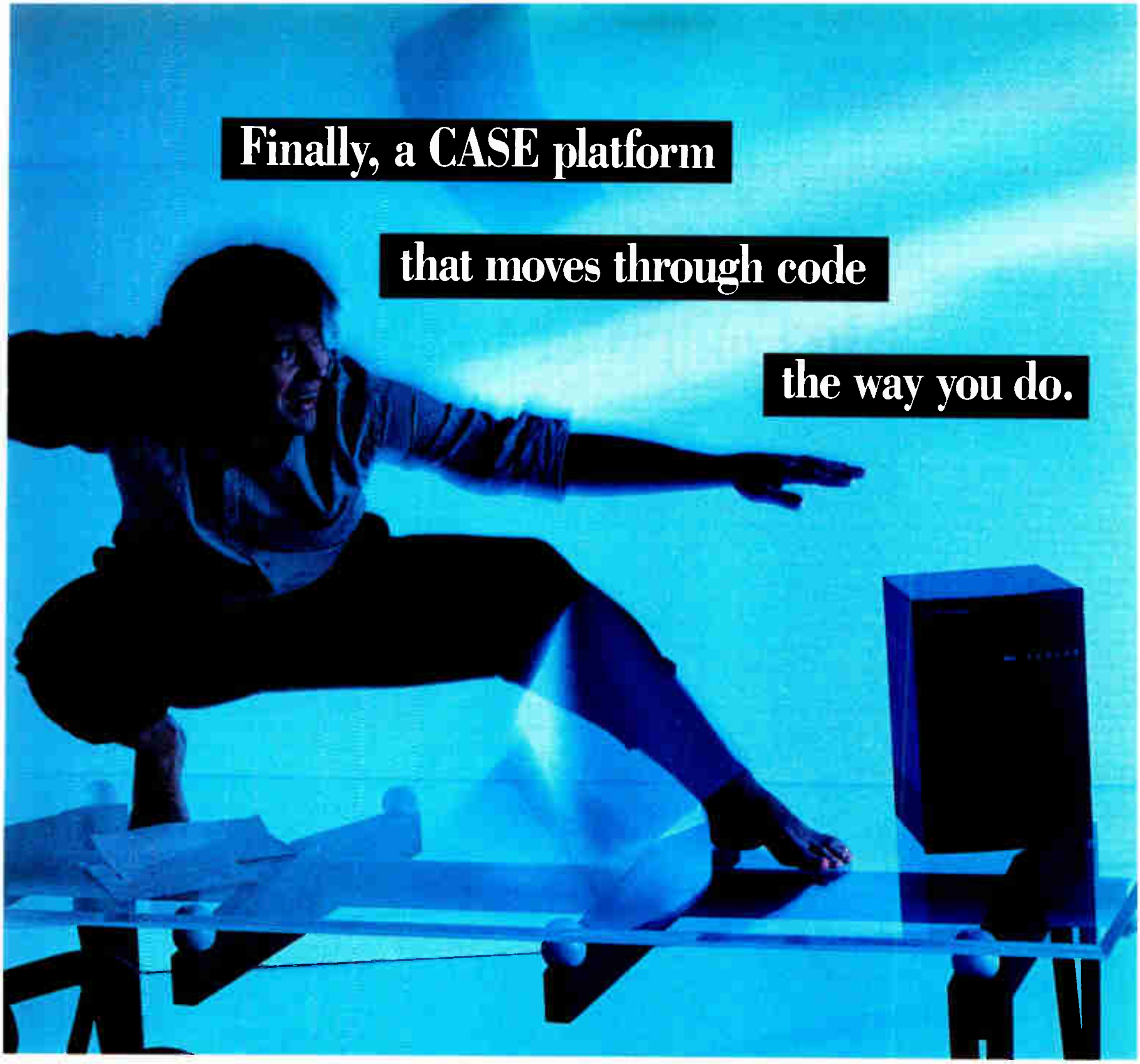
This new organization's real value is its generality. For example, if the ring has enough bandwidth, one engine can perform the computations necessary to process the pixels of each geometric primitive. The pixels that are not under its part of the footprint would be sent over the ring to the proper engine for final rendering in a z-buffer. More important, because the ring allows an arbitrarily large number of processors to work on any rendering algorithm, ray tracing and radiosity are possible. With enough processors, you have realistic, real-time 3-D graphics—the only problem is the cost.

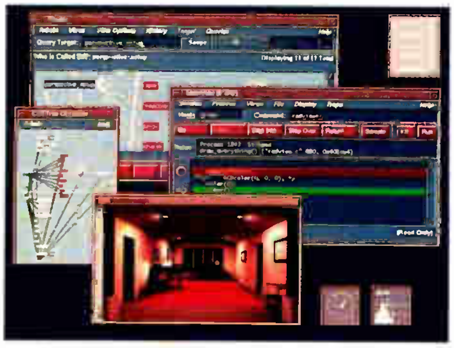
Reducing the Cost

The hardware required for 3-D graphics is relatively expensive because the market is small. But this market is growing fast, and the cost of high performance is plummeting. Moreover, a new force is emerging that will help drive the cost of 3-D graphics down: digital TV.

Digital TV needs computing capability for control of such things as multiple windows, variable transmission resolutions, encryption, and compression. I call this *high-resolution digital television*—the phrase that really should define the acronym HDTV. Because many of the requirements for this new industry are similar to those of texture mapping in photo-realistic graphics, much of the work required to do realistic real-time graphics will have already been done. This enormous new market will justify the development of specialized modules for graphics, audio, and video that, if properly designed, will also be used in desktop and portable computers. For the consumer market, they must be low-cost.

Semiconductor manufacturing costs are surprisingly low. A silicon chip containing a state-of-the-art CPU has up to 2 million transistors and costs the manufacturer less than $40 to fabricate. For a CPU, this amounts to about 50,000 transistors per dollar. At the same time, manufacturers spend about $1 to produce 50,000 bytes





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A Programmer's Guide to Computer Graphics

JOEL N. ORR

If you've never programmed graphics, the array of tools, aids, and environments can be confusing. Manufacturers of computer graphics hardware design their products without much regard for the concerns of anyone but their most immediate customers. To support these devices, they produce software libraries that tie into a customer's facilities through common programming languages, such as FORTRAN, Pascal, or C.

But if your investment in graphics is to survive changes in computers or I/O devices, it must be buffered from the specifics of hardware. Figure A shows where these buffers go.

What Goes Where

The various buffer layers can be loosely classified as follows. High-level programming environments (e.g., AVS, VI, and Easel) are discipline-oriented programming environments built on top of applications programming interfaces or systems programming interfaces. APIs (e.g., PHIGS, GKS, GKS 3D, and Hoops) insulate programmers from the details of specific libraries or hardware. I/O formats (e.g., IGES, PDES, CGM, GKS metafiles, and PostScript) provide for data exchange among systems. SPIs (e.g., IRIS GL, XGL, PEXLIB, and Starbase) ease a programmer's task in some of the same ways that APIs do, but they provide more control over the graphics hardware. Device drivers, such as CGI, simplify the connection of I/O devices.

Programming Tools

Graphical standards, environments, languages, and formats continue to proliferate. Some of the most widely used are described below.

CGI (*computer graphics interface*) provides rules for exchanging device-independent data and control information among graphical systems, where the "systems" might be pieces of hardware or simply graphical-device drivers. CGI defines an idealized abstract graphics device that can accept input and generate, store, and manipulate pictures.

CGI also contains provisions for generating and controlling the appearance of graphical primitives; interrogating graphics device capabilities, characteristics, and states; controlling graphics devices; generating and controlling groups of primitives called *segments*; obtaining graphical input; and creating, manipulating, and displaying raster bit maps. This interface supports only two-dimensional output primitives and controls only one output device.

CGM (*computer graphics metafile*) is a "snapshot" of the image created by a program. It's formatted as an ordered set of elements for describing pictures in a device-independent way. It supports both vector and raster data. Several pictures can be stored in one metafile, and they can be randomly accessed within the file. CGM syntax allows the incorporation of nongraphical information and graphical elements that have not been standardized. This extensibility can also be a weakness. Some software developers have added their own frills and objects to the files, and the CGM interpreters of other packages cannot read these.

Core is an early effort by a Siggraph group and is now principally of historical interest.

Dore, the Kubota graphics library, was designed to support scientific and engineering visualization applications. Dore is similar to Hoops in that it is declarative, but it has more rendering methods than Hoops. Although parts of the package are portable, Kubota does not guarantee software implementation of missing hardware functionality.

DXF (*data exchange format*), Autodesk's file format for AutoCAD, is one of the most widely used external data file formats. Because it's designed by a company to support its own needs, it's less general in the types of geometry it supports than IGES.

GKS (*graphics kernel system*) is an ANSI and ISO standard for 2-D graphics. GKS provides a functional description of a 2-D interface that supplies most of the facilities applications require to produce computer-generated pictures. Programmers can use relatively abstract graphical primitives and input classes and leave the details of manifestation in a particular hardware environment to the GKS package.

GKS-3D is a superset of GKS that is a separate standard defined for 3-D. It has facilities for hidden-surface and hidden-line removal.

Hoops was developed by Ithaca Software (San Francisco, CA) and is a popular API. It has been adopted by CADAM, Computervision, Auto-trol Technology, and other CAD vendors to make their code as platform-independent as possible. Hoops is declarative rather than procedural.

IGES (*initial graphics exchange specification*) is a widely used ANSI standard (Y14.26M). It's a method and format for describing geometry for system-independent storage and communication of CAD data. CAD vendors need only provide mechanisms to translate their proprietary formats into and out of IGES.

Because it must accommodate all known CAD systems, IGES offers many ways to define geometry. This is both a strength and a weakness. If IGES translators are designed by two CAD companies, it's likely there will be many conflicting definitions. Consequently, the concept of *flavoring* translators has evolved: The translators and procedures restrict geometry types in one system to those that can be

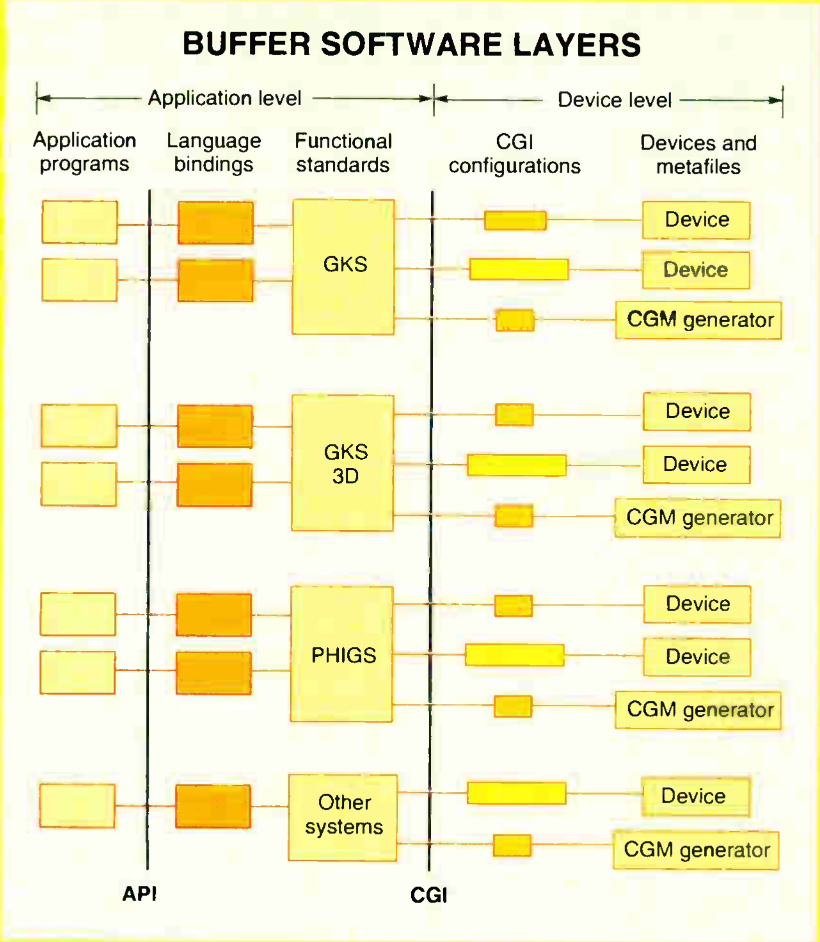

Figure A: *Several layers of buffers have been developed between the application programmer and the graphics hardware. These layers can be grouped as shown in this reference model.*

translated into formats meaningful in the other system.

IRIS GL is a proprietary set of routines that is being promoted by Silicon Graphics as a useful standard on other platforms. It's a software interface to graphics hardware, consisting of several hundred procedures and functions that allow a programmer to specify the objects and operations involved in producing high-quality graphical images. It accepts information describing simple geometry and geometric manipulations (e.g., transformation and lighting parameters) and creates raster data in the form of a series of frame-buffer addresses and values.

IRIS GL expects the graphics hardware to have a frame buffer, and much of its functionality is addressed to the control of such a device. Its strengths are in rendering (i.e., the production of photo-realistic color imagery, especially of 3-D objects). IRIS GL follows the client-server model for interpretation of its commands. A program—the client—issues commands, which are then interpreted and processed by IRIS GL—the server. This model simplifies implementation of IRIS GL on a network, where an existing protocol (e.g., X Window System) carries the commands and the results between the client and the server.

PDES (*Product Data Exchange using STEP*) uses the lessons learned from years of IGES use to expand the notion of the neutral data file to encompass nongeometric product-related data, such as product material and finish. STEP (Standard for the Exchange of Product Model Data) is a European standard for engineering-data exchange that has been accepted by the IGES/PDES community.

PEXLIB has been adopted by most of the leading workstation vendors. Its functions are similar in level to those of Silicon Graphics' IRIS GL or Sun's XGL. They are low-level procedural functions.

PHIGS (*programmer's hierarchical interactive graphics standard*) allows objects to be hierarchically related to other things, obviating the need for multiple copies of similar objects in a file. For example, all four wheels of a car model might actually be just one piece of geometry that is referred to four times.

PHIGS+ is an extension to PHIGS that includes shading and complex geometries. Most workstation vendors feature PHIGS+, even in some firmware.

PostScript is Adobe's widely used page-description programming language. It has powerful typeface-definition and -manipulation capabilities and can handle raster and vector data.

QuickDraw is the graphics library built into the Mac system ROM, which rarely receives the credit it deserves for the Mac's interapplication smoothness.

RenderMan is Pixar's 3-D format for photo-realistic image processing. Pixar is promoting it as a standard for 3-D imagery for visualization and animation.

Starbase is Hewlett-Packard's hardware interface library, which is equivalent to IRIS GL and XGL.

Windows GDI and Metafile is a Windows graphical-device interface. Instead of having to support every conceivable graphics adapter, Windows developers need only support the Windows GDI.

XGL is Sun Microsystems' proprietary graphical library for X-based systems.

Joel N. Orr is a CAD/CAM and computer graphics consultant. He is a founding member and past president of the National Computer Graphics Association. You can reach him on BIX c/o "editors" or at 1-800-CADD/CAM.

of DRAM. In five years, manufacturers will spend the same amount to produce 250,000 transistors or 0.25 megabytes of DRAM.

Then why are these devices so expensive? For that matter, why are the computers they are contained in so expensive? There are several reasons. First, all companies try to make a profit, and some companies with unique products charge the maximum the market will bear. Second, chips are put in packages that often cost more than the chips themselves. Third, there are always intermediaries involved before a computer manufacturer buys the chips, and they extract their profits, too. Finally, add the computer manufacturers' costs and profits. What started out costing very little becomes quite pricey.

With about 6 million transistors and 15 MB of memory, it's possible to construct a rendering system as powerful as the most advanced graphics systems available today. Such a system could not only render polygons with textures but also input, decrypt, and decompress a digital TV signal. It would have enough power to map arbitrary input resolutions to different output resolutions (e.g., convert HDTV input to standard NTSC). Properly structured, it could also be used in the new graphics architecture discussed earlier. In short, if you had to pay only manufacturing costs, you could do just about everything you wanted to do for about $350 today or $90 in five years.

Who's Going to Make It?

Who is going to make and sell this computing/memory module? It will require a company that has a consumer electronics–market orientation and a long-term market-penetration view. The company will need people who know how to design the system and write the software. It must be a semiconductor company that can make both the processors and the memory. Finally, the company should be able to make multichip modules and avoid all the intermediaries.

Such a company could manufacture and profitably sell these computing/memory modules for about $1000—too expensive for the consumer market. But in a few years, a module for under $200 is certainly possible. This opportunity will create a company to fill this need if an existing firm doesn't accept the challenge.

Where We're Headed

Computer graphics is finally as fundamental to computers as vision is to humans, and soon, 3-D graphics will be in the home and available in portable and desktop computers. Of course, 2-D will also be around because it's a subset of 3-D.

Even though real-time 3-D graphics emerged almost 30 years ago, its greatest growth has occurred in the last five years, when it became more affordable. This growth rate will accelerate as the world begins to appreciate the applications for 3-D graphics.

As recently as 1984, there were people who couldn't understand this passion for real-time interaction. I once demonstrated an intelligent real-time information system to a reporter who said, "I can't visualize why you need all these graphics." Today, the needs are obvious, and the applications are all around us.

Real-time graphics is demanding. It requires specialized hardware to bring realism into the interactive realm, and this hardware is expensive. But semiconductor technology and consumer electronics will provide the avenue for cost reduction.

As digital TV becomes real in the next few years, it will give birth to new computer technology markets that will dwarf those of today. These new markets will require many other computing technologies in addition to graphics. As cable TV merges with telecommunications via digital fiber optics, the client-server model for computer systems will find its biggest application in the new local loop. Computer companies will supply media servers —digital TVs—to home clients. The TV will effectively become a telecomputer. Video and audio entertainment on demand will be the biggest uses, but the implications for education are immense: real-time interactive books that teach through simulation, video, and audio. The telecomputer will also provide an environment for interactive media (e.g., magazines, newspapers, and virtual reality games). And this will all happen by the year 2000.

New Business Model

Semiconductor technology will fuel dramatic progress in these new areas, but business models in this industry will have to change. Telecomputer manufacturing will require almost everything to be done by one company—a company that can fabricate semiconductors, knows computer graphics and video technology, and takes a long-term view of the consumer electronics marketplace.

This is a big order, but we've seen such companies emerge in Japan in the last 20 years. Will this one be from the U.S.? It's anyone's guess. ■

Jim Clark is the founder and chairman of Silicon Graphics Computers, a leading manufacturer of 3-D computing systems. You can reach him on BIX c/o "editors."

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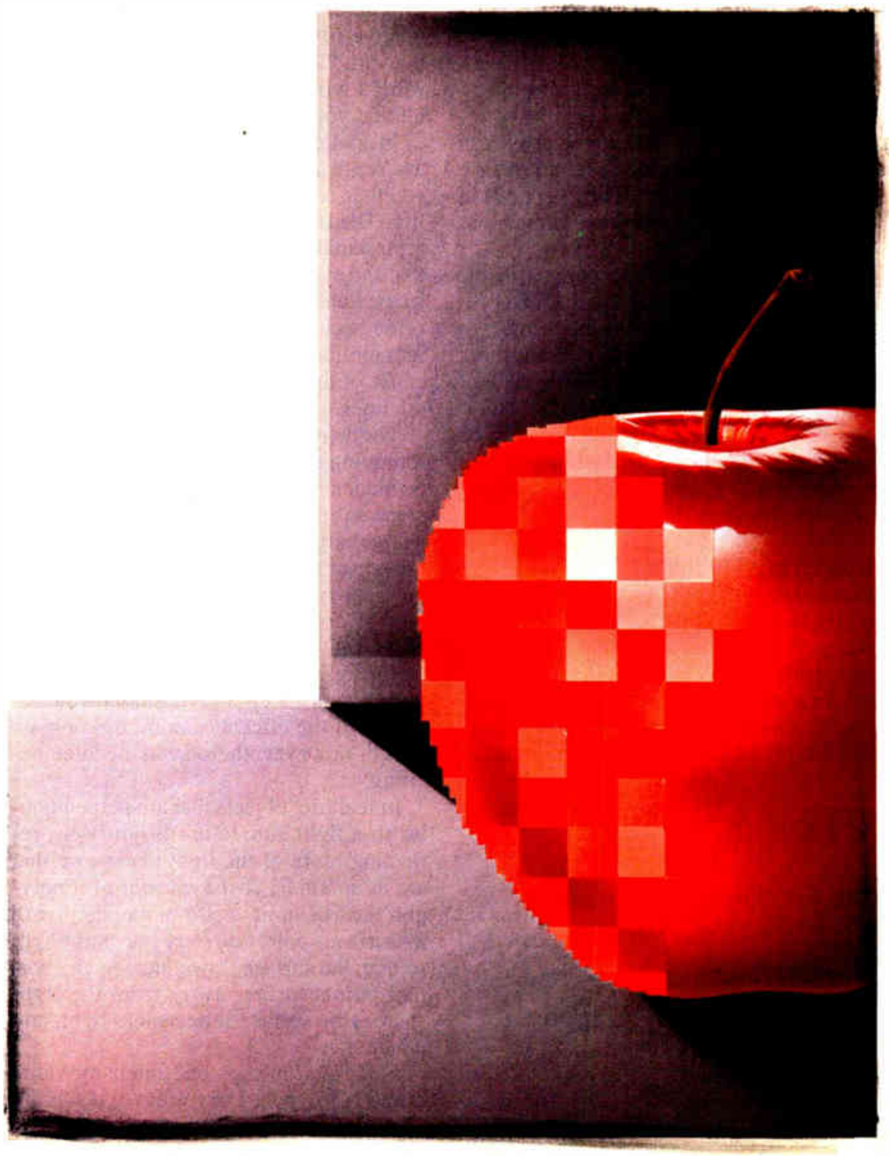
PHOTO-REALISM

Computing images that look like real objects and scenes

EVAN YARES



There are few things so mysterious as how a computer program can create a lifelike three-dimensional picture—not just any picture, but one that can fool the human eye. Sometimes the only clue that a computer-generated image is not real is the fact that it exceeds reality as people normally perceive it. A computer, or more correctly a computer artist, can create a picture of the dark side of the moon, and only our knowledge that it can't be real prevents us from accepting it as such.

Although computers are unconstrained by physical laws, they create images using mathematical models of those laws. More often than not, the math must be simplified because computers—even supercomputers—are not infinitely fast. Still, creating images that look realistic enough to be photographs (or are *photo-realistic*) is difficult. Even though some very fast computers (e.g., the Iris 4D/VGX workstations from Silicon Graphics) can generate impressive images in real time, none can achieve true photo-realism at interactive rates.

Creating photo-realistic images involves two broad steps. An artist must create a mathematical model describing the scene, and then the computer must *render* that scene into an image file containing a color value for each picture element (or pixel).

Scene Description

In the first step, the computer artist describes the objects, lighting, and "camera angle" of the scene. The most important primitive object is the polygon in 3-D space. More complex objects, such as spheres and cured surfaces, are typically made up of groups of polygons known as *meshes*.

continued

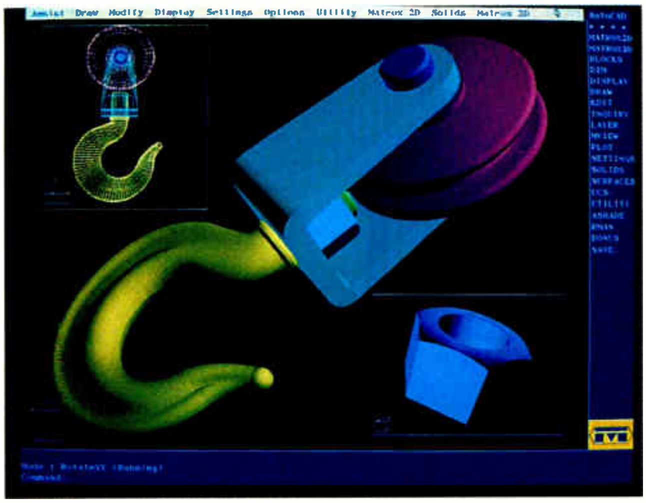


Photo 1: *This AutoCAD design can be rapidly otated in real time because the Gouraud calculations are supported by a Matrox MG-3D graphics board. Gouraud shading doesn't produce bright highlights, so the surfaces in this image appear opaque and plastic. (Courtesy of Matrox)*

To reduce complexity (at least in the scene-description phase), Pixar and a few other software developers use mathematically generated curved surfaces (often called *surface patches*). This method is particularly useful in describing nonuniform surfaces. Instead of having to modify individual polygon vertices, the artist can modify the curves that define the surface patch. As images are rendered, these patches are decomposed, or *tessellated*, into polygon meshes.

Beyond describing the objects in the scene, the computer artist must also describe the lighting and the camera angle, or viewpoint. When describing the lighting of a scene, the artist specifys the type of light source (ambient or point), its color, and its position. The camera angle is the simplest aspect of scene description, but it is the one that determines what objects are seen from which angle.

Rendering Methods

Rendering is the process where the magic really happens. The most realistic methods are often the most computer intensive, and absolute realism is not always practical. In a rendering of an office, for example, shadow and light help convey important information. In a rendering of a sunken ship, however, too much shadow and light can obscure information. In fact, the real-time animation of an object's motion or change of state may be more important than producing a realistic rendering; therefore, a wireframe image of the object is all that you need.

In a wireframe image, all surface edges are represented as lines and are shown whether or not they would be seen in real life. The basic problem with a wireframe representation is that it leaves ambiguities that the eye cannot resolve. Draw a wireframe cube, and you can't tell which side is the front. But once you put a wireframe into motion, the ambiguities fall away because of the relative motion of the different lines.

The wireframe is greatly enhanced by removing the portions of lines that would be hidden if the polygons of the wireframe were solid and opaque. There are good general algorithms for hidden-surface removal (or *visible-surface determination*), but none make the task easy.

Shading

Coloring in the surfaces of an object is only a small step above hidden-line removal. If the effects of point lighting are added, however, the objects become exciting.

In real life, objects that are perpendicular to a light source are brightly lit, reflecting more of the light than those that are at an angle. If the *normal* of a polygon (i.e., the unit vector perpendicular to its surface) points directly at a point light source, the surface is brighter. As the normal points farther away from the light source, the surface reflects less light, and it is darker.

Flat shading uses one intensity value for each polygon. The result is a distinctly faceted look. This method is fast and easy, and it's usually adequate for quick views and flat surfaces.

If the objects are composed of smooth curved surfaces, flat shading leaves much to be desired. But the general concept of flat shading is greatly enhanced by interpolation, or the blending of the color shades of adjacent visible polygons. This requires that a scene be constructed with meshes rather than individual polygons.

With the most common color-intensity-interpolation method, *Gouraud shading*, the color-shade interpolation occurs at the edges of polygons. Many graphics workstations and a few personal computer graphics cards (see photo 1) implement Gouraud shading in hardware.

Phong shading interpolates the surface normal of every polygon pixel-by-pixel with respect to adjacent visible polygon normals. Because these normals are used to determine diffuse reflection (and, hence, surface color), the net effect is that Phong shading is smoother than Gouraud shading. A side effect, however, is that Phong shading is much more processor intensive than Gouraud shading. Generally, Phong shading is implemented in software rather than hardware, and it's not fast enough for real-time display.

Phong shading can generate surface and edge highlights (*specular reflections*). By varying a surface's specular reflectivity from matte to shiny, the highlights change from broad and soft to small and sharp. Because color (and reflection) is calculated for each pixel on each polygon, the specular reflection is always properly shown, even in the middle of a polygon. Since Gouraud shading does not interpolate color intensity in the middle of polygons, any specular reflection there would not be visible. For the most part, specular reflection, or Phong lighting, is used with Phong shading rather than with Gouraud shading.

Phong shading alone has a distinctly smooth, opaque quality, which is acceptable for representing plastic but little else. The majority of the photo-realistic images you might see are created with Phong shading and a variety of special effects, the most common of which are textures, bumps, shadows, reflections, and transparencies.

Textures

One way to refine an image is to create a more detailed model with more and smaller polygons. However, there is a point of diminishing return when adding detail with additional polygons. One alternative is *texture mapping*, the application of images onto a surface, much like the application of decals onto a toy model.

BYTE ACTION SUMMARY

The creation of photo-realistic 3-D images requires a mix of sophisticated techniques and an abundance of computer power.

Texture maps can be scanned or stored images (the easiest method), or they can be created by a software procedure. High-end rendering programs, such as Alias Studio and Pixar's photo-realistic RenderMan, use procedural texture maps. They are more accurately called *shaders* because they define the shading of the objects to which they are applied. Although writing a shader program just to create a texture may seem a little extreme, it is sometimes the only way to get acceptable results. Consider velvet—a scanned texture map won't show the nap of the cloth properly, but a procedural shader will.

Because texture maps are generally flat and the objects to which they are applied are not, there can be some interesting complications. Think how difficult it would be to apply a map of the world to a sphere, and you'll get some idea of the problems.

Overall, texture mapping can add tremendous detail to a rendered image without increasing its geometric complexity. A rectangle can become a painting, or a sphere can become a globe. Even though texture mapping is usually handled by software, some workstations (e.g., the Iris 4D/VGX) can apply texture mapping in real time through hardware.

Although texture mapping goes a long way toward adding detail to renderings, it still lacks depth. The surfaces continue to look geometrically smooth. A *bump map* is an array of displacements that slightly alter the normals underneath a surface. Because the normals are perturbed, the results look like bumps. It's an illusion (look at the silhouette of a bump-mapped object, and you'll see that it's smooth). A more advanced technique, *displacement mapping*, can displace the surface of an object. Displacement mapping must be applied early in the rendering process because it affects visible-surface determination. In fact, it could be considered a postprocessing operation to scene creation because it changes the object geometry.

Photo 2: *A tremendous degree of realism can be achieved with ray tracing, a technique that is particularly valuable in creating images of objects with transparent or reflective surfaces. This complex image was generated on an Intergraph workstation using Intergraph's I/EMS, Microstation, and Modelview. The engineer/artists were Dan Stiles, Jim Cashion, and Tim McElyea of Intergraph. (Courtesy of Intergraph)*

Light and Surfaces

Shadow casting would be easy if it were limited to one object and one light at a time. In that case, projecting the silhouette of an object on a ground plane would be sufficient. But the use of a fake shadow is rarely adequate. Close lights can distort shadows. Objects falling in a shadow's path can complicate matters, too. Accurate shadow determination is identical to visible-surface determination except that it's from the viewpoint of the light source (instead of the camera) and must be repeated for each light source.

Not all objects have a matte surface. Some, such as chrome, are shiny enough to reflect the image of other objects. *Reflection mapping* (also known as *environment mapping*) is used to simulate the effect of a reflective surface. Essentially, reflection mapping is a trick, where the objects to be reflected are rendered from the viewpoint of the reflecting object. That image is applied as a texture map. This is a gross simplification, but some variation of this method can usually be made to work.

Transparency is one of the most difficult effects to create. Because of refraction, light does not travel in a straight line. Objects seen through a transparent object are distorted. If the effects of refraction are not important (e.g., when looking through a flat window), it's easy enough to fake transparency. The transparent object becomes a simple color filter. Any object behind the transparent object is shown, but with its color value altered.

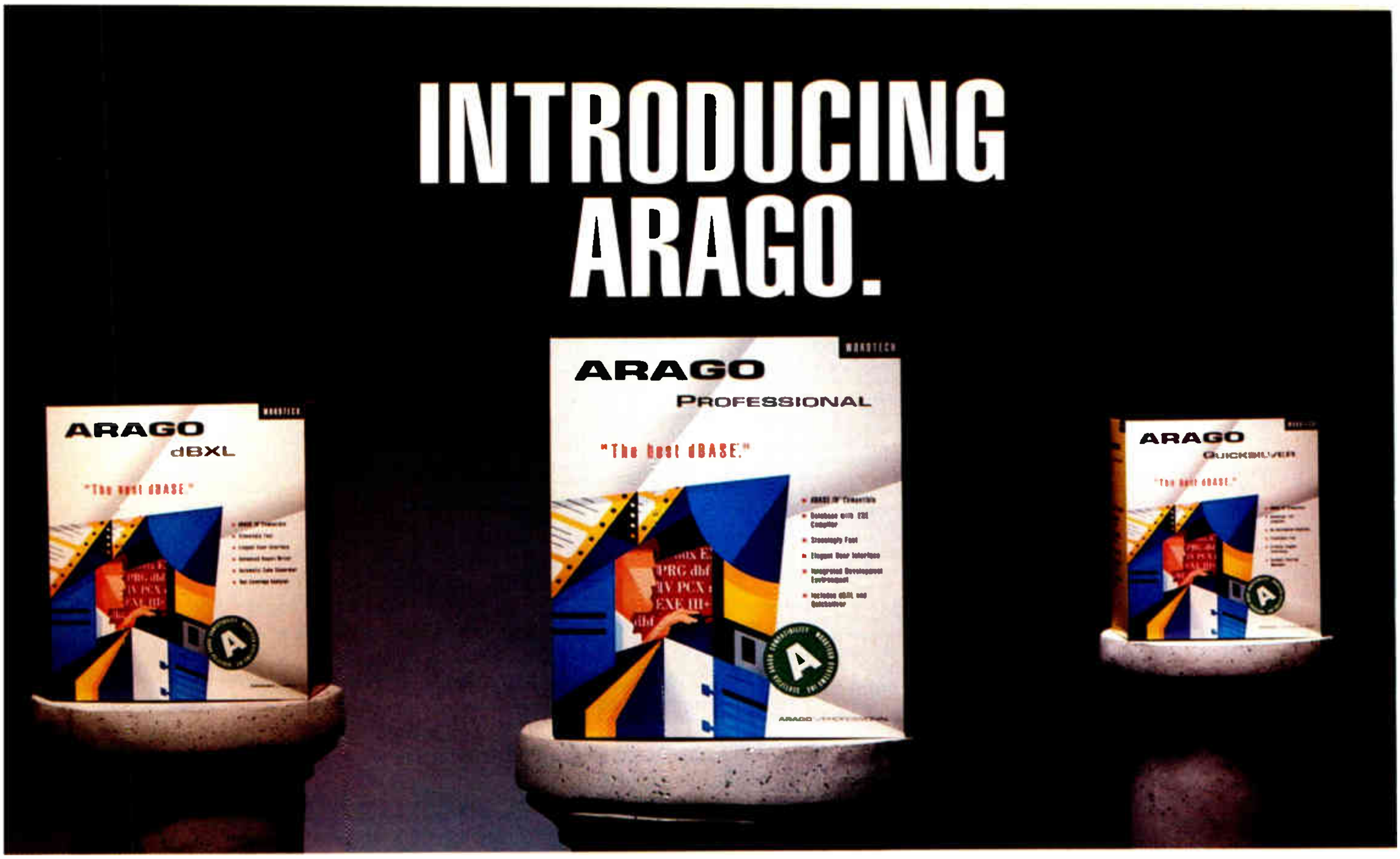
Ray Tracing and Radiosity

In some cases, it's not enough to fake shadows, reflection, or refraction. The values must be calculated. In these cases, the rendering method of choice is *recursive ray tracing*. This method traces beams of light from the viewer's eyes back to the light sources and accurately renders shadows, reflections, and refractions. Ray tracing is computationally intensive because at any point of intersection a light ray will spawn shadow, reflection, or refraction rays. The reflection and refraction rays may spawn another set of rays. This spawning process goes on until the ray reaches a light source or has an insignificant light value.

To determine the intensity value of each pixel of an image, all the rays for the pixel are arranged in a tree, with the viewpoint at the top and the spawned rays branching out below. The ray tree is evaluated from the bottom up, summing all the intensities up to the viewpoint. This process is recursive, consuming tremendous computer resources. Because of this, it's common to limit the depth of analysis to a small number of reflections or refractions. The process is rather like looking at a mirror that faces a parallel mirror. Theoretically, the reflections should go on forever, but there is a practical depth beyond which you can't tell the difference.

It would be difficult to trace rays from the light source, following only those that end up at the viewpoint. By tracing rays in reverse, the result is the same (because light energy is conserved), but the process is easier.

Because ray tracing requires so much computing time, few rendering systems use it as the sole method of rendering. Ray tracing is most valuable for modeling reflections and refractions (see photo 2), so it's often combined with Phong shading, texture mapping, bump or displacement mapping, and reflection mapping (where



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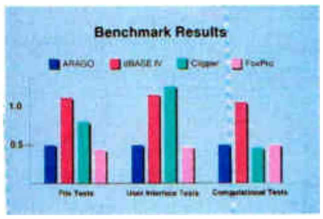

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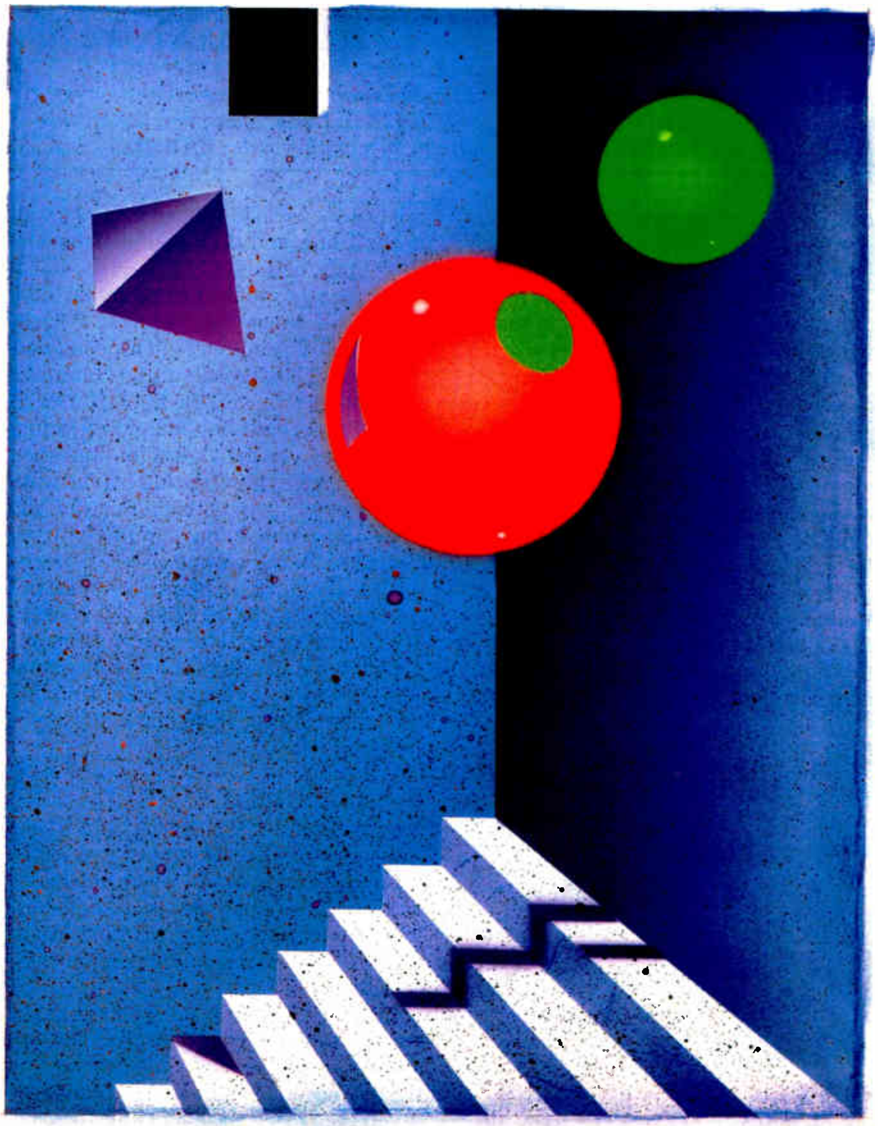
RADIOSITY

Calculating the diffuse lighting and shadows of realistic images

JOHN WALLACE AND JOHN FUJII



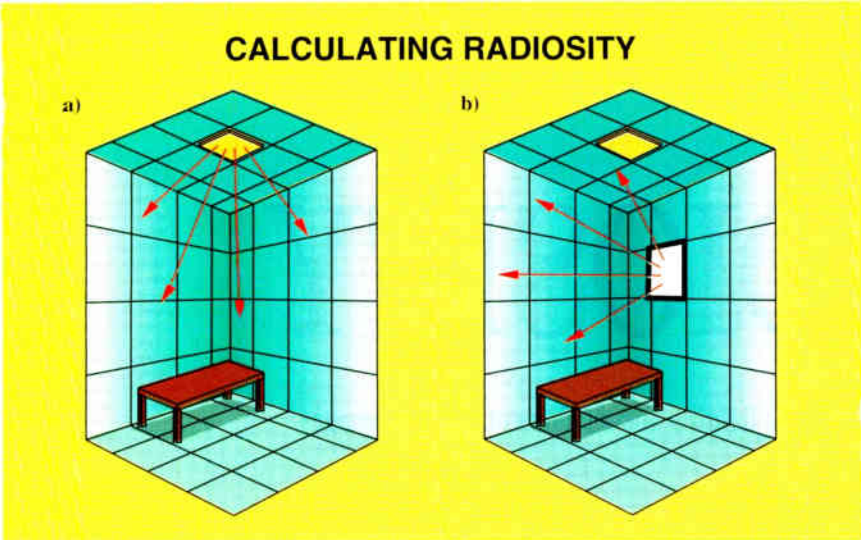
The appearance of real surfaces depends on complex interactions among light, color, and material. The equations used by ray tracing and common rendering software handle specular reflection but do not account for one of the most important interactions: the interreflection of light between matte, or *diffusely reflecting*, surfaces. Radiosity methods treat diffusely reflecting surfaces correctly: Objects are illuminated not only by light emitters, such as light bulbs, but also by light reflected from other objects.

Shortcomings of Ray Tracing

Ray tracing can produce spectacular images—as long as those images contain mainly shiny or transparent surfaces. Real environments are often largely composed of diffusely reflecting surfaces, such as painted walls and carpeting. Ray tracing is not particularly good at simulating the shading of this type of surface, and ray-traced images containing such surfaces are often disappointing.

Diffusely reflecting surfaces cause trouble for ray tracing because they reflect light in a way that works against ray tracing's basic strategy. Ray tracing follows a ray's reflection from a surface to determine the point of illumination. (For more information on ray tracing, see "Photo-Realism" on page 167.) This process is very efficient if the surface is a mirror. Since mirrors reflect light in only a single direction, only one ray has to be traced to determine what would be seen in a mirror at any given point.

Diffusely reflecting surfaces behave just the opposite; they reflect light in all directions with equal intensity. A ray tracer would have to trace rays that reflect in



The process of calculating radiosity: The surfaces of a model are first split into small patches. **(a)** *The energy of the light sources is radiated to all other patches.* **(b)** *Light is then radiated from one reflecting patch to all other patches, and a new value is calculated for each. The process is repeated until a lower limit of reflected light is reached. This process calculates values that remain constant no matter what view is used for the final rendering. As a result, once the radiosity has been calculated, the calculation of each frame in a motion series is relatively fast.*

many directions to figure out the shading at any point on a diffusely reflecting surface.

Any of these rays that reflect and happen to hit another diffusely reflecting surface would, in turn, spawn a whole new generation of reflection rays. The time required to generate an image in this way is impractical, even by ray-tracing standards.

Ray tracers usually simplify the shading of diffusely reflecting surfaces by ignoring the light that other surfaces reflect onto them. Unfortunately, in environments like the interior of a building, much of the actual illumination is due to reflected light; for example, in most rooms, the ceiling receives light, even though there are often no lights pointed directly at it. The light illuminating a ceiling may originate at a window, bounce from a wall to the floor, and then bounce from the floor to the ceiling.

Imagine the problem an algorithm faces trying to determine the shading of the ceiling, which depends on light reflecting off the floor. The algorithm must compute the light reflecting off the floor. However, that light depends on the light reflecting off the wall, so the algorithm must then compute the light reflecting off the wall. Even worse, the light that reflects off the floor will probably contain the light reflected from the ceiling itself. It seems that the illumination of every surface depends indirectly on the illumination of every other surface. The effect of this reflected illumination is often subtle, but it can play an important part in providing the sensation of realism that many applications demand.

BYTE ACTION SUMMARY

Radiosity allows the calculation of the effect of light on diffusely reflecting surfaces. It also lets computers provide real-time interaction with realistic three-dimensional images.

Radiosity Method

Many advances in computer graphics have come when researchers turned to scientific or engineering fields, where analogous problems have often been solved. Radiosity methods originated in the fields of radiant-heat transfer and illumination engineering.

In analyses of problems in these fields, the surfaces of an environment are broken up into small pieces, or *patches* (see the figure). The transfer of radiant energy between each patch and every other patch is then computed, typically by solving a matrix equation. In radiosity algorithms for computing light interreflection, each small patch is a potential source of light energy. A few represent actual energy emitters, like light bulbs, but most provide only reflected light, which you can think of as virtual light sources.

In a commonly used algorithm called *progressive radiosity*, the computation of light-energy transfer proceeds in a series of incremental steps. At the beginning of this computational process, the energy of the reflecting patches in the environment is 0. The initial steps of the calculation must first determine the illumination reaching each reflecting patch directly from the actual light emitters.

After this phase is complete, the amount of direct illumination that every reflecting patch receives is known. Each patch absorbs some of the light that reaches it and reflects the rest back into the environment. In the next phase of the process, one reflecting patch after another is selected and treated as a virtual light source, with its reflected energy radiated out as if it were a true light emitter. Aside from the fact that the source of light is reflected rather than emitted, there is no difference between computing the effect of reflectors and the actual light sources.

The calculations of energy transfer between a source and a receiving patch must account for shadowing caused by intervening objects. One approach is to trace rays from the source to the receiver to detect any such objects and to reduce the total energy transported between the two patches accordingly. Other factors that affect the amount of energy transferred include the patch sizes, the orientation, and the distance between the two patches being considered. The net outcome is a transfer of energy (possibly 0) from one source to all other receiving patches.

During the process, as successive patches are chosen as the source, the rest of the patches in the environment accumulate additional energy. Each patch may be considered as a source more than once during the process, thus taking into account multiple interreflections (e.g., light bouncing back and forth between a floor and a ceiling). Because absorption is a major factor in a diffuse environment, no patch reflects all the energy it receives for any step. Energy transfer diminishes as the process progresses, and the computation stops when it drops below a specified limit.

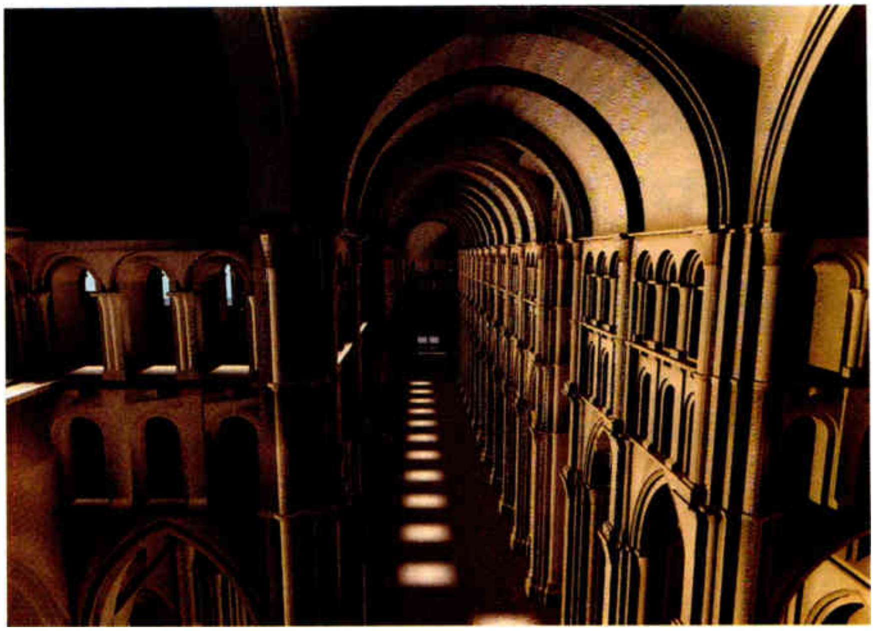
One Step from an Image

The final result is that the light energy leaving every patch is known, and the shading of the environment's surfaces is determined. This is quite different from the result obtained following ray tracing or other rendering algorithms, which produce an intensity value for each pixel in an image, based on a particular eye position.

Radiosity does not render an image. In fact, in the preceding description of the solution, an eye position has not even been mentioned. The process has simply added shading information to the surfaces of the scene. You need not choose the view until after the process is complete, at which point a rendering algorithm performs the perspective transformation, determines the visible surfaces, and interpolates the precomputed shading data to produce the final image (see the photo).

Most important, after an image has been rendered for the selected view, you can choose another view and render a new image using the same precomputed shading. The diffuse shading precomputed by radiosity is independent of the view.

Although the radiosity process may take from minutes to hours to complete, the speed at which new views can be generated depends only on the speed of the software or hardware used to render the final image to the screen. The radiosity process is ideal for personal computers or workstations with three-dimensional graphics accelerators or software for fast polygon rendering. If the renderer is fast enough, the final step can be repeated in real time, with the view specified interactively using a mouse or a joystick. Therefore, radiosity provides one of the first opportunities for applications to take advantage of real-time interaction with realistic images.



The effect of diffuse lighting is that objects that do not receive direct lighting are illuminated by the lit objects near them. The left side of the hall is lit by the light bouncing off the right side. The image was rendered using HP's Advanced Rendering Technology on an HP Apollo Series 700 TurboVRX using data generated by ASB Baudat CAD Service GmbH with IEZ Speedikon software.

Applications

In the field of architecture, the ability to combine photo-realism with interactive rendering opens up new possibilities for the presentation of designs. It is expensive and time-consuming to prepare and present realistic hand renderings of plans to a client. If you can enter or extract a 3-D model description from an existing computerized plan, it is suddenly possible to generate a variety of radiosity-shaded views from any perspective. The client can explore a realistic computer model during the presentation to learn the relationships of plan elevations to the real world and to gain a sense of what it will be like to walk through a newly constructed building.

Radiosity's accurate simulation of illumination also offers architects and interior designers a tool for lighting design. It is possible to evaluate the spacing of ceiling lights in an office or to experiment with the placement of windows to take best advantage of daylight.

For CAD and industrial design, one of the values of interactive rendering is that it lets you move around a model to better understand its 3-D geometry. The soft shadows provided by radiosity can make the relationship between surfaces immediately evident. When realistic shading is combined with interactive viewing, complex geometry can become much easier to understand.

Radiosity is already available in commercial applications and programming libraries—for example, Hewlett-Packard's ARTCore radiosity and ray-tracing library. The ARTCore library has been licensed to Ithaca Software for use in a multiplatform Hoops product. Radiosity is also available to end users of the Wavefront Personal Visualizer on HP workstations and as an option for the HP ME30 mechanical design package.

Working Together

Radiosity has limitations, and these limitations have formed the basis for continuing research. Radiosity alone does not provide highlights, reflections, or refraction, since it is limited to diffusely reflecting surfaces. These effects are important not only for realism but for providing visual cues about geometry and surface quality. The inclusion of nondiffusely reflecting surfaces in the actual view-independent radiosity process is expensive. Fortunately, it is possible to partly add these effects during the rendering phase, with effective results. For example, you can add highlights to a radiosity image by simply turning on specular highlights in the graphics accelerator while it renders the radiosity polygons for any particular view.

Even more striking results can be obtained by using a ray tracer as the final rendering engine. Some of the most dramatic images produced to date are the result of combining radiosity and ray tracing. Undoubtedly, future algorithms will draw inspiration from both approaches. ■

John Wallace is a software engineer at 3D/Eye, where he is the project leader for the development of Hewlett-Packard's ARTCore radiosity and ray-tracing library. He received his M.S. from the Program of Computer Graphics at Cornell University, and he is the author of several papers on the topic of radiosity that have appeared in the SIGGRAPH proceedings. John Fujii is a graphics engineer working at HP's User-Interface Technology Division in Fort Collins, Colorado. He works on HP's advanced visualization products, the ARTCore programmer's library and tool set. You can reach them on BIX c/o "editors" or on Internet at johnw@eye.com and fujii@hpfujii.fc.hp.com, respectively.

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Software integration capabilities	8.34	7.26	7.24	6.27	6.10
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Documentation & product information	8.74	6.73	6.56	6.45	5.56
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VOXELS: DATA IN 3-D

Voxels are samples of volume data from real-world instruments. You can use them to see inside just about anything.

VINCENT ARGIRO AND WILLIAM VAN ZANDT

Flying logos, special effects in the latest sci-fi film, walk-through architectural design—these are the ordinary applications of three-dimensional computer graphics. Now, however, a new form of 3-D computer graphics is changing the way scientists and engineers represent and study the world.

For a while, researchers in the 3-D graphics field have been experimenting with new ways to more accurately visualize data. Two principal directions look promising. The first is an improvement in the rendering methods and the means of interacting with volume representations. In this area, among the key elements are stereo viewing, 3-D pointing devices (e.g., 3-D mice, wands, and gloves), and faster and less-expensive displays. The second area of development is an advancement in the methods of interpreting data sets.

A new wave of imaging technology is changing the way people analyze all kinds of data, from the microscopic analysis of DNA to the simulation of cosmic jets spewing from radio galaxies. It's affecting the methods used to search for oil deposits far beneath the ocean floor and to devise safe ways of manufacturing exotic materials used to send the space shuttle into orbit. This turn of events is being led by an unassuming character with an unfamiliar name: the voxel.

Meet the Voxel

Voxel. A word you may never have heard of. *Pixel*. Now you're probably on more familiar ground. As you may have guessed, both words are related. *Voxel* is derived from *pixel*.

A pixel is a picture element: a tiny 2-D sample of a digital image. It has a specific

location in the plane of a picture, defined by two coordinates (usually x and y). A pixel has a value that indicates its visual contribution to the picture. The value may be 1 bit, indicating black/white or simply visible/invisible, or the value may be 24 bits or more, encoding separate channels of information for RGB or other visibility properties of the pixel.

BYTE ACTION SUMMARY

A new form of 3-D computer graphics is changing the way scientists and engineers represent and study the world and analyze data. Consider using voxels, or volume elements, as a way to sample the 3-D space that an object occupies. Voxels provide you with information not just about the outer surface of objects but also about the substance within.

A voxel, or *volume pixel*, is a sample that exists in a 3-D grid, positioned at defined x, y, and z coordinates. Each voxel also possesses a value, but a voxel's value is rarely used to represent a simple color or other visibility property. Instead, a voxel's value represents a sample of volume data from real-world scientific or medical instruments.

Two Views of the World

When you hear the phrase *3-D computer graphics*, you might think of CAD models, flight simulators, or special effects in movies. Practically all these applications are built on the concepts of geometric graphics or surface rendering. During the early development of computer-imaging hardware technology in the 1960s and 1970s, the first algorithms for representing objects or scenes in a 3-D world focused on boundaries.

The simplest example of this approach is the wireframe model—actually a 3-D form of line drawing captured mathematically in the computer. The next phase of the technology, surface rendering, is a process in which a mesh of polygons replaces the network of lines or vectors.

The polygonal model can be elaborately shaded to simulate the play of light and shadow on the object or scene, endowing each polygon in the image with known or imagined surface properties. These enhancements lend considerable realism to the model, giving you more of a sense of looking through a window into a virtual world.

Although the object or scene looks promising from an external vantage point, if you look inside this polygon-mesh boundary representation (b-rep for short), you find nothing. Emptiness. The model is a hollow shell lacking the solid continuity you know exists in the real world. How can you fill this void with substance and complete the virtual reality?

Voxel, enter stage left! Instead of modeling or capturing a piece of the world as a boundary representation, why not consider sampling the entire 3-D space enclosing an object or scene? Without regard to the content or arrangement of objects in space, simply subdivide the whole 3-D region into many samples.

You can choose a resolution to distinguish the smallest features of interest, just as you would select pixel resolution in 2-D. Then pick one or more properties of the materials or phenomena in this space and take their measure at each location.

The values at specific locations are voxels, or volume elements. Now you have information not just about the outer surfaces of objects but about the substance within and the environment without. Instead of viewing a substitution for the data as represented by abstact geometries or hollow shapes with no inherent content, you are endowed with 3-D vision and the ability to navigate through the actual data, establishing new perspectives and achieving new insights. You see detail and structural complexity in 3-D that would overwhelm a model based on surfaces alone.

Scan Me Up, Scotty

It turns out that acquiring a voxel representation of a 3-D space is as easy as pushing a button—admittedly, in some cases, a very expensive button. But the point is that most voxel data sets are not created in a computer. Voxels are generated by various instruments, particularly 3-D raster-scanning instruments.

Perhaps the most familiar example of these instruments is the x-ray computerized tomography (CT) scan machine. This scanning process beams x-rays through an object from many angles around its circumference. The amount of transmitted radiation is measured and used (by a set of algorithms known as *back projection*) to compute a 2-D image of one slice of the object. This process is repeated at many points along one axis of the object, resulting in a stack of slices.

Taken together, these slices make up a volume data set, with the pixel samples in the slices now being properly considered voxels. X-ray CT scan machines measure the mass density of objects. Materials of different densities can be distinguished by their recorded voxel values. The application of these instruments is very common in industrial inspection and medicine.

A more recent voxel-spewing instrument that is revolutionizing biological science is the laser scan confocal microscope (LSCM). In the early 1980s, this device was developed concurrently in a number of variants by several university and commercial laboratories around the world. At least eight companies offer commercially manufactured versions of this instrument, ranging in price from $50,000 to $200,000.

The LSCM produces a voxel volume by scanning a highly focused laser beam across a microscopic plane inside a semitransparent specimen and recording the light reflected or produced by fluorescence with a very sensitive detector. The resolution in the laser's scanning plane can be better than 0.2 micron.

The special arrangement of the instrument's optical elements filters out light coming from above or below the plane of sharpest focus. This process yields a thin (less than 1 micron) slice, or optical section, of the biological tissue or sample. As in a CT scan, this 2-D scan is repeated at intervals along one axis of an object, creating a 3-D data set consisting of many voxels.

These are only two examples of voxel-producing instruments. There are many others, including magnetic resonance imaging (MRI), 3-D seismic imaging, 3-D ultrasound, and electron-microscope tomography. You can see that these instruments are able to generate a lot of data. For instance, a typical confocal-microscope volume data set consists of 50 slices, each 512 by 512 voxels in resolution—512 by 512 voxels by 50 slices, or 12.5 million voxels. Each voxel value is often stored as 1 byte of data; thus, this sample data set is 12.5 MB in size. As the resolution and/or field of view of any instrument increases, the data sets can grow much larger (ranging into the gigabytes for 3-D seismic surveys).

A New Kind of Computer Picture

To derive maximum information from voxel data, you need to visualize the relationships among the structures of the volume. This key requisite is accomplished by using the entire voxel data set to create an image—a technique known as *volume rendering* or *volume imaging*.

Volume rendering relies on two principal methods. The first method, called *image ordering* (or *ray casting*), positions the volume behind the picture plane. A ray is projected perpendicularly from each pixel in the picture plane through the volume behind the pixel. As each ray penetrates the volume, it accumulates the properties of the voxels it passes through and adds them to the corresponding pixel.

If you interpret the volume as highly transparent, the voxel contributions gradually accumulate as the ray passes through them. If you interpret the volume as more opaque, the contributions quickly reach a saturated state, and the ray casting stops. Because it saves time, the principal advantage of this approach is its ability to stop the rendering when opacity is at a maximum.

The other method, called *object-order* (or *compositing* or *splatting*), also combines the voxel values to produce image pixels. The image plane is positioned behind the volume, and each pixel is assigned an initial background value. A ray is projected perpendicularly from the image plane through the volume to the viewer. As the ray encounters each successive layer of voxels, the voxel values are blended into the background, forming the image according to each voxel's interpreted opacity. It's as if the volume were held up in front of the picture plane and pressed flat against it.

The advantage of this sequential back-to-front compositing of the voxels is that you can watch the image creation as it reveals the volume's internal structure. Unlike traditional surface-rendering methods, volume rendering is a direct-rendering method. Direct volume rendering uses the entire voxel data set to build the picture—you don't need an intermediate model.

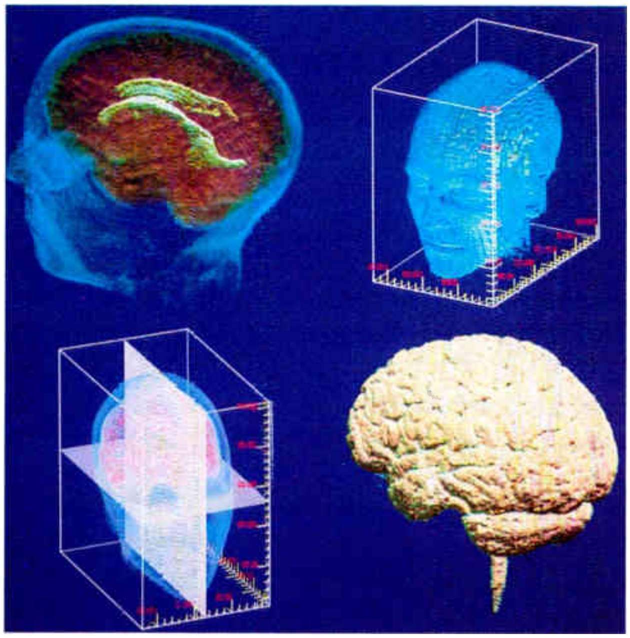
Alternatively, you can attempt to extract surfaces of interest from the voxel data set by using an automatic algorithm, such as the well-known marching-cubes method, or by manually tracing contours on the individual volume slices.

Choosing a surface-extraction method imposes limitations on your work. Before you start the visualization step, you must decide which voxels you're interested in. You have to throw away most of the voxel data in this procedure. In addition, you may find it difficult to determine where a supposed surface cuts through the volume.

It's difficult to locate surfaces when the original data is contaminated with random noise, as is often the case with real-world instruments functioning at the limits of their sensitivities. Furthermore, some voxel data (e.g., a fuzzy gradient) doesn't lend itself to surface extraction. You can represent fuzzy data more completely with direct volume renderings.

Keys to Recognition

With direct volume rendering, you can accurately visualize your data as a 3-D image, just as it was gathered from your data



An MRI data set rendered in various ways to emphasize different attributes of the volume. The upper-left image is an external view of the head, rendered opaquely and encased in a bounding box. The annotated-scale values help to calibrate the volume. The upper-right image shows the skull rendered transparently so that you can view the brain. (Courtesy of Dr. Eric Courchesne, Children's Hospital, San Diego, CA)

source. The specification of opacity need not be inherent in the original voxel data, because you can arbitrarily assign it from a table before you begin the rendering.

For example, with an x-ray CT data set, you can create a lookup table to modulate opacity according to mass density. Therefore, in a medical application, bones appear opaque, and soft tissue is transparent, revealing the bones within. By creating a table that assigns high-opacity values to the soft-tissue data, you see the tissue as opaque because it shows a "normal" exterior view.

Color plays an important role in communicating information contained in voxel data. The human eye is exquisitely sensitive to small differences in hue. By using color instead of simple shades of black and white, you increase your perception of subtle differences in voxel data. Additionally, you can choose colors to highlight relationships among the voxels.

Although voxel data doesn't inherently represent color, you can add color to the voxels. Using the medical x-ray CT as an example, when a lookup table maps the mass-density values for muscle in red and the values for bone in ivory, the image takes on a lifelike quality when it is rendered.

Even if the original objects in the volume do not have true colors, you can apply pseudocolors to illustrate contrasts among the voxel values. For instance, seismic data is often visualized with different colors representing different amplitude values in the image. Coloring seismic data is particularly powerful when you render the image with maximum transparency. In this case, the few colors you assign to input voxel values blend to produce a larger palette of intermediate colors. This blending makes slight variations in the data more apparent.

To delicately blend colors in volume rendering, the system must combine the voxel contributions (either by ray traversal or back-to-front compositing) with RGB component color representations. In most practical implementations, this process usually means you must have 24-bit color.

Getting Up to Speed

When you're building practical implementations of volume rendering, one of the issues you must immediately address is interactivity. Being able to interact with your data depends on the raw speed of the rendering process. Typically, when you make a change in the rendering parameters, you want to instantly see the results of that change on the computer screen.

A CAD or conceptual design program achieves an acceptable redraw time handling a few thousand geometric primitives. A volume renderer, however, must rifle through millions or tens of millions of voxels to build each rendering and still achieve an acceptable redraw time.

Until recently, the staggering increase in input data for a 3-D display process has delayed broad acceptance of volume rendering. The number of voxels needed to do the job places tremendous demands on all aspects of a computing system.

For instance, you must consider the throughput of the rendering "engine" itself. On a microprocessor, even minimal volume-rendering algorithms require at least 50 to 100 machine instructions per voxel to bind color and opacity attributes, project the voxel onto the pixel grid, and blend the voxel's attributes with others along the same line of sight. Unassisted, even the fastest of the RISC crop cannot manage more than about a million voxels per second.

Then, of course, you must usually hold in RAM the data from the volume being displayed. This process consumes at least 16 to 32 MB—some labs routinely use 256 MB. Also, archiving large-volume data sets taxes mass-storage reserves, using hundreds of megabytes of disk space.

If developers remove some of the processing burden from the CPU, they can make volume rendering run faster than 1 million voxels per second. You can usually enhance performance by transferring the specialized-image computer tasks to specialized display hardware. This hardware often consists of one or more custom math coprocessor chips. You can use massive parallelism to perform this task.

These kinds of enhancements are appearing in personal workstations. Increasing interest in volume rendering as a core capability of personal workstations will further inspire platform vendors to produce more and better products in this area. In the next year or two, you may see more products targeted to the volume-rendering market. Also, the continuing fall in the prices of high-density RAM and mass storage will help this evolution take place.

Worlds Collide

You know the advantages that volume rendering offers over conventional geometry-intensive 3-D graphics. And it should be said that the best of both, used in combination, is better than either alone. Volume rendering has substantial advantages when it's applied to scanned volume data to visualize internal relationships with a minimum of a priori interpretation. In the evaluation of such data, however, its interpretation is crucial. In this context, *interpretation* refers to segmentation, or classification and measurement, of features or objects in the volume data set.

As researchers pick out features of the volume data using volume renderings as a 3-D road map or virtual world, they see a simpler representation emerge. This "cartoon" of the data set might become a stick figure of a highly branched nerve cell during the study of brain development or an outline of the cerebral cortex in an MRI scan of a patient's brain (see the photo). These diagrammatic elements are economically represented to the computer as vector networks or polygonal meshes, and they are rendered to the screen using standard 3-D computer graphics techniques.

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In the past, computer graphics users had to make a tough choice between representing their data in volume-rendered or geometric-model form. Recently, researchers have developed methods to merge the two displays in the same 3-D visual space. You can embed geometric elements in volume-rendered data like reinforcing rods buried in cast concrete.

You can peer through the transparent outer layers of an object of study at a model located inside the volume and see precisely how well your interpretation matches your instrument's output. This ability provides a critical quality-assurance step in voxel data interpretation.

Beyond Tools to Applications

Now that you have set the stage and signed on the players, you're ready for the real fun to begin. Without some value added, visualization programs are intrinsically interesting for about 3 minutes after you take them out of the box. Beyond that, your satisfaction depends on how many useful tasks you can perform with them. Because the images created by these new volume-rendering tools are so intuitive and because there are huge and growing sources of volume data, scientists and engineers are realizing an amazing variety of applications for these tools.

Volume microscopy is one of the most exciting voxel applications. And with the LSCM, biologists can take their experiments out of the test tube or culture dish and perform them in the natural environment of the cells and tissues. Cells are becoming miniature 3-D laboratories.

One advanced researcher using confocal microscopes is Steven Senft of the McDonnell Center for Higher Brain Function at Washington University. He has been using volume visualization and analysis to study mouse brain nerve cell growth.

Senft has assembled a system of software tools with which he can control a confocal microscope, acquire volumes of data, process raw data, build 3-D volume images, and perform volume measurements—all on the same personal workstation. With this visualization workbench, Senft can study brain development in unprecedented detail. Because he can generate and analyze data so quickly, he is able to perform experiments in days or weeks that might have taken months or years to complete less than a decade ago. For example, Senft is studying the volume of a single nerve cell—a simple-sounding experiment, but not a simple task to perform. Nerve cells and their multibranched processes are extremely complex.

In the past, scientists would measure these cells by laboriously hand-tracing each 2-D slice that made up the volume. Today, working with volume seed-filling algorithms and geometry-embedding techniques, a researcher points the cursor at the cell of interest, and the system automatically searches the cell and calculates its volume in a matter of seconds.

Even better, in this process, researchers can validate the measurement by visualizing the seed-filled cell while it is embedded in its tissue environment. They make adjustments to the opacity, resulting in the newly measured cell's standing out from its neighbors. Using these measurements, researchers can build 3-D models of cell growth, insert their models into volume data from real brains, and test their theories about brain development.

Looking Beyond the Status Quo

From the microscopic scale of cells to the expanding scale of the universe, volume-investigation tools are beginning to form the nucleus of a new generation of imaging laboratories. These new tools are starting to close the loop between experiment and theory in unexpected ways.

Where are this technology and its potential applications headed? Many think they may become as ubiquitous as the geometry-based 3-D computer graphics methods that permeate CAD, animation, architecture, and presentation graphics.

Alan Trimble, director of special projects at Silicon Graphics, one of the leading vendors of workstations for high-performance voxel processing, commented that there are more people who need to use visual computing with data derived from real-world instruments than there are those who use visual computing for conceptual design or visual simulation.

Beyond these techniques lay applications for 3-D extensions to pattern recognition, including image algebra, AI, and neural-network learning systems. In interpreting volume data, the parameter space is so large and the degrees of freedom are so great that many scientists increasingly view assistance from the computer to build the best possible image as essential.

Over the next few years, you may see voxels, volume imaging, 3-D image processing, and volume-rendered animation become an integral part of most scientific, engineering, and medical disciplines. ■

Vincent Argiro is cofounder and CEO of Vital Images (Fairfield, IA). William Van Zandt is cofounder of Vital Images, and he is the company's director of business development in volume microscopy. You can reach them on BIX c/o "editors" or on Internet at argiro@vitalimages.com. and bvz@vitalimages.com, respectively.

3-D DISPLAYS

The combination of fast computers and innovative display techniques makes possible a variety of systems for creating and manipulating realistic 3-D images

DAVID F. MCALLISTER

The past 10 years has seen rapid advancement in three-dimensional techniques and technologies. Hardware has improved and become considerably less expensive, making real-time, interactive manipulation of true 3-D computer-generated images possible. Today, 3-D imaging is becoming an important tool in such areas as molecular modeling, photogrammetry, flight simulation, CAD, visualization of multidimensional data, medical imaging, and virtual reality. The improvements in speed, resolution, and economy in computer graphics are just one part of the 3-D equation. The development of liquid-crystal polarizing shutters, liquid-crystal parallax-barrier methods, and multiplanar displays has made the interactive manipulation of 3-D computer-generated images an important and useful capability.

This article discusses how advances in 3-D technology have been incorporated into commercial 3-D display devices. I've limited the discussion to technologies capable of producing computer-generated images that can be manipulated interactively. Before delving into the technology, it's important to first understand how humans perceive depth.

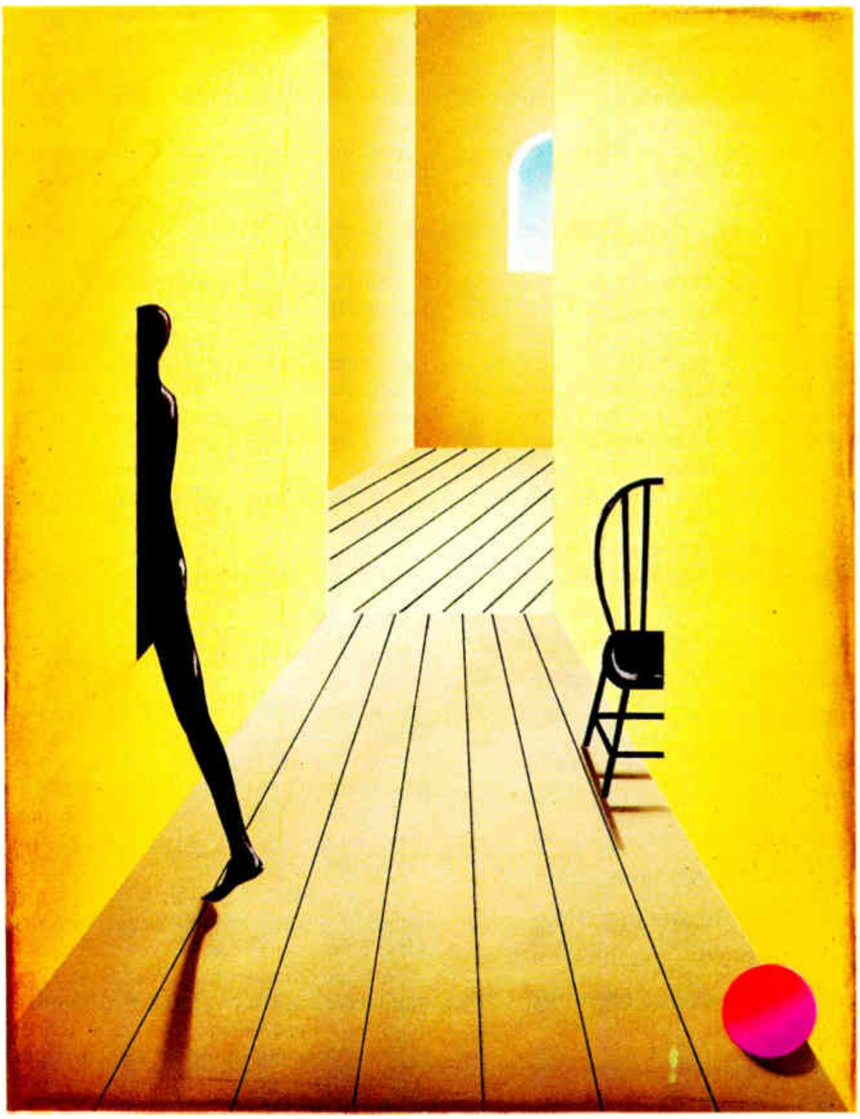
Depth Clues

The human visual system uses several depth cues to distinguish the relative positions of objects in a 3-D scene. These cues are divided into two categories: physiological and psychological.

There are four primary physiological clues:

Accommodation is the change in the focal length of the eye's lens as it focuses on specific regions of a 3-D scene.

continued



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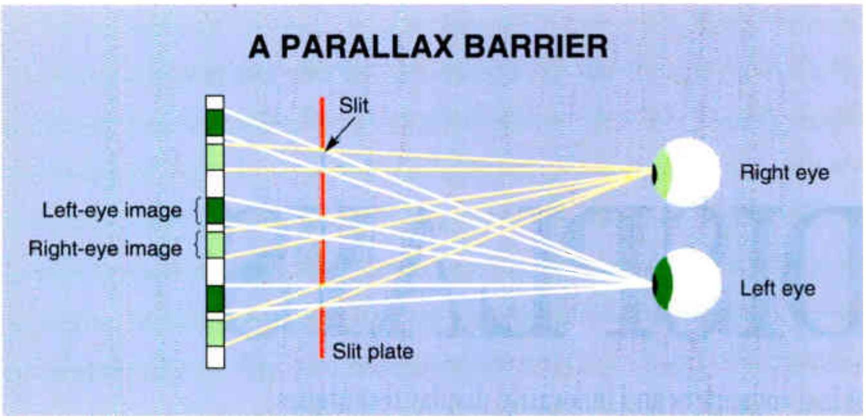

Figure 1: *This cross section of a parallax-barrier system, seen from above, shows how the system sends different images to each eye. When you are the proper distance from the slit plate, each eye sees only the image strips meant for it. The slit plate occludes information meant for the other eye.*

Convergence (or simply *vergence*) is the rotation of the eyes inward to converge on objects as they move closer to the observer. (If the presentation of an image requires the eyes to rotate outward beyond the normal parallel position for observing a scene, it's described as being *walleyed;* images that require this condition are not correctly presented.)

Binocular disparity is the difference in the images that are projected on the left and right eyes when they are viewing a 3-D scene. The visual system uses this salient depth cue to produce the sensation of stereopsis, or depth.

Motion parallax provides differences in views of a scene by moving the scene or the observer. You can determine the depth of two points by observing how much they move relative to each other. As you move your head from left to right or up and down, the points closer to you appear to move more than the points farther away. This is called the *look-around* capability. Moving your head produces different views of the scene.

Psychological depth cues include the following:

Linear perspective is the property of vision that causes the size of an image on the retina to change in inverse proportion to changes in the distance between the object and the eye.

Shading and shadowing are important lighting properties in a scene that help you determine the shape and depth relationships of objects by their positions with respect to light sources.

Aerial perspective is the property that causes objects that are farther away to appear less distinct and cloudy.

Interposition (or *occlusion*) occurs when an object hides or overlaps another. You assume the object hiding or overlapping the other object is closer. Retinal image size and your knowledge of the world and the size of objects also help you determine the depth of objects. If you perceive the height of an elephant to be the same as that of a mouse, you assume the mouse is much closer than the elephant.

Texture gradient helps you determine depth by the amount of detail visible on an object.

Color is used in various ways to sense depth. In general, brightly colored objects appear closer than dark-colored objects.

Normally, depth cues are additive: The more there are, the easier it is to determine depth relationships in a particular scene. In some situations, however, certain depth cues are more powerful than others. For example, the effects of interposition can be so strong that they overpower those of binocular disparity. In situations like this, you can perceive depth relationships that are anomalous.

BYTE ACTION SUMMARY

Interactive 3-D displays use physiological and psychological cues to create 3-D images. The displays come in three types: stereo pair, multiplanar, and holographic. The first two, although they have limitations, are commercial realities. Holographic displays—the most capable—are not yet commercially viable.

Types of 3-D Displays

Most 3-D displays fit into one or more of three broad categories: *holographic*, *multiplanar*, or *stereo pair*. In general, holographic and multiplanar displays produce "real," or "solid," images within which the physiological depth cues are consistent. These images do not require special viewing devices and hence are called autostereoscopic. They normally have the look-around property.

Holograms are perhaps the most familiar form of 3-D displays. To create a hologram, you record the interference pattern produced by two laser beams originating from the same source on a very high resolution photographic medium. One beam strikes the recording medium directly, and the other bounces off the objects in a scene and interferes with the reference beam. The interference pattern allows the reconstruction of the original scene.

By moving horizontally (or, in some cases, moving horizontally and vertically, depending on how the hologram was made), you can see continuously changing views of the scene. Holograms can also contain psychological depth cues (e.g., interposition and color). The technology, however, has not advanced to the point where it permits interactive manipulation of computer-generated images.

In stereo-pair displays, left- and right-eye 2-D images are directed to the appropriate eye. These displays depend on binocular disparity to produce the sensation of depth. Displays based on stereo pairs normally require special viewing devices, and they don't have the look-around property. Stereo pairs produce a virtual image. Because you focus only at the plane of the stereo pair, accommodation is fixed. Accommodation and vergence are thus disconnected. This inconsistency can make some scenes difficult to "fuse" (i.e., to interpret as a 3-D image, as opposed to seeing two separate flat images).

Stereo Pairs in Depth

In general, stereo-pair technologies are the least costly of the 3-D display technologies that can be used effectively with workstations and personal computers. These technologies take advantage of the full-color photo-realistic images that you can produce and manipulate using computer graphics techniques. The disadvantage to using stereo-pair technologies is that a large number of people have some degree of stereo blindness: They are unable

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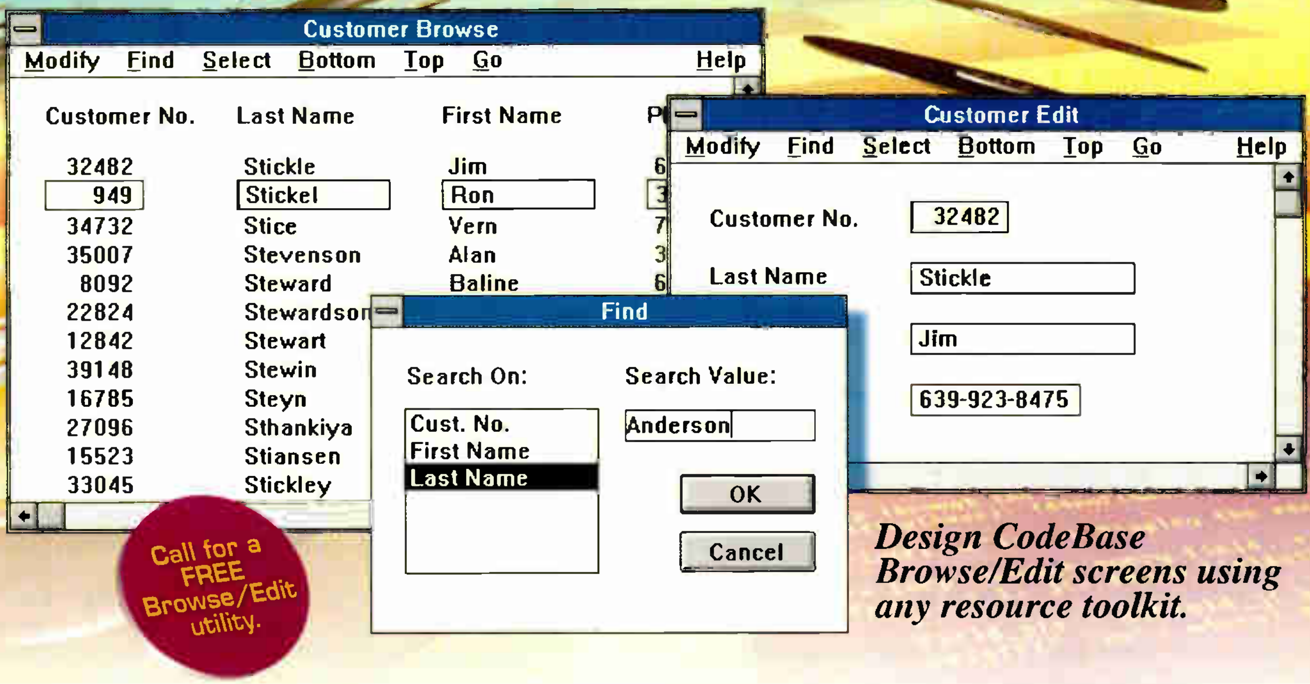

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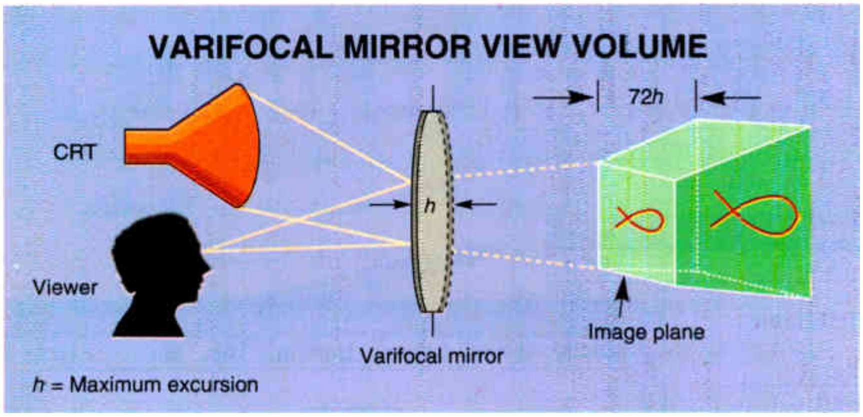

Figure 2: *The image magnification is 1.26 when the mirror is concave and 0.83 when the mirror is convex. The shape of the view volume is a frustum of a rectangular pyramid. The software transforms the view volume into a cube. The system can plot 16,000 points in the movement from front to back. About 10 points per centimeter are required to produce a line without severe aliasing, and the total length of the lines in an image cannot exceed 1600 cm. The image is transparent, and each point can have one of 256 intensities. You can manipulate the images interactively with a computer. This technology will produce points and wireframe transparent images in only one color.*

to use the left and right 2-D images to perceive a 3-D image.

Stereo-pair technologies fall into two broad groups. *Time-parallel* systems present both eye views simultaneously. *Field-sequential*, or *time-multiplexed*, systems present the left- and right-eye images in sequence, using optical techniques to occlude the right eye when the left-eye view is being presented and vice versa.

The best-known example of a time-parallel presentation is the ViewMaster. It provides the left- and right-eye images simultaneously. Head-mounted displays are another example of time-parallel systems, as are 3-D movies, which traditionally use the old anaglyph method that requires you to wear glasses with red and green filters.

The main problem with old-style 3-D movies is a phenomenon called *ghosting* or *cross talk*. Because the filters don't eliminate the opposite-eye view, each eye sees not only its image but sometimes part of the image intended for the other eye. This results in headaches for moviegoers, giving 3-D in general, and stereo pair in particular, a bad reputation.

A more modern time-parallel approach used to show stereo slides and animations to large audiences places orthogonally oriented polarizing filters in front of two projectors. The projection screen is metallic, and it maintains the polarization of the reflected light. To see the image, you wear passive polarized glasses in which the polarization is consistent with the filters on the projectors. This blocks the right-eye image from the left eye and vice versa. However, because polarization reduces light intensity, the image is dimmed.

Some hand-held viewing devices (e.g., the Stereoscope by Stevens Scientific Products) allow the simultaneous presentation of both eye views of a stereo pair on a computer display. These devices are inexpensive and use simple optics. They do, however, require that you hold your head still, and prolonged viewing may cause physical discomfort. This technique also limits the size of each eye image because both views are present on the screen at the same time and are nonoverlapping.

Parallax Barriers

One interesting time-parallel technique uses vertical lines, or a parallax barrier, to block the left-eye image from the right eye and vice versa (see figure 1). The image is recorded in strips behind the parallax barrier. Recording several different stereo pairs in strips and registering them correctly behind the parallax barrier provides a degree of the look-around property, although the change in scene is not continuous as you change your position. The technique is becoming very popular for printing static 3-D images using high-resolution color laser printers. The parallax barrier is printed on one side of a transparent medium, and the image strips are on the other side. Backlighting the display is required because the barrier blocks a considerable amount of light.

Recent advances in electro-optics have made possible computer-driven parallax-barrier displays. Dimension Technologies (New York, NY) manufactures a color display device based on parallax barriers that is autostereoscopic. The display can be driven by a Mac or a PC. The system uses a transmissive image-forming display—essentially an LCD in front of, and spaced apart from, a special illumination plate. The plate produces many thin, bright vertical illuminating lines, with a dark space between each line, and with one line for every two columns of pixels. Sitting at an average viewing distance from the display, you see all the light lines through the odd-numbered columns of pixels with the left eye and through the even-numbered columns with the right eye. Because the display is transmissive, there must be illumination behind a pixel before the pixel can be seen. The left-eye view of a stereo pair is displayed on the odd columns, and the right-eye view is displayed on the even columns.

Field-Sequential Presentation

Field-sequential presentation devices (which display the images to each eye sequentially) have made rapid progress in recent years. Early field-sequential systems used mechanical devices to occlude the appropriate eye during CRT refresh. The images alternate in sequence: When the left eye is occluded, the system displays the image intended for the right eye. Similarly, while the right eye is occluded, the left-eye image is presented. Consequently, these systems require at least two internal buffers—one for each eye—and a mechanism for switching between the two buffers at CRT refresh speeds. For best results, you need a CRT with a 120-Hz refresh rate. Each eye is presented with an image at 60 Hz, significantly reducing flicker. With field-sequential displays, the image size is not sacrificed, because the left- and right-eye views alternate.

Two electro-optical techniques are supplanting mechanical field-sequential devices. They use liquid-crystal technology and polarization to either transmit or occlude an image from a CRT to the appropriate eye. One technique uses "active" glasses, and the other uses "passive" ones.

StereoGraphics (San Rafael, CA) makes a system that uses active glasses. A "stereo-ready" computer uses an infrared emitter to send a synchronization signal to the glasses. Based on the signal, the glasses (lightweight LCD glasses powered by batteries) alternately occlude and transmit the image displayed on the system monitor to each eye.

The company 3D TV (San Rafael, CA) makes an inexpensive active-glasses system for PCs. Because it depends on the

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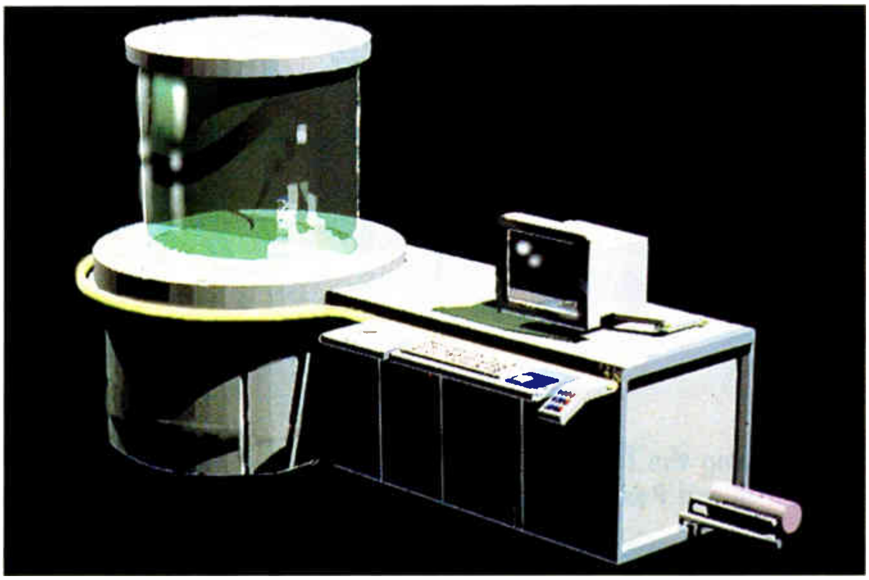

By reflecting lasers off a rotating mirror, Omniview creates a series of 2-D images, which your eye fuses into 3-D shapes. (Courtesy of Texas Instruments)

refresh rate of your monitor (which is usually below 60 Hz for PCs), you may perceive some flicker in the image unless the monitor brightness is adjusted, the room lighting is subdued, and the image is low contrast with a gray background.

The passive-glasses method employs an LCD shutter attached to the front of the display device. To use the system, you must wear polarized glasses, similar to sunglasses. The shutter switches the polarization of the light emitted from the screen at 120 Hz. On refresh, the light is polarized circularly in one direction. The lens on the glasses that is polarized in the same direction as the polarized light allows the light to pass through to that eye. The lens that is polarized in the opposite direction doesn't allow the light to reach the eye. On the next refresh cycle, the LCD shutter polarizes the light in the other direction and continues to alternate with each refresh cycle. StereoGraphics and Tektronix (Beaverton, OR) market such systems.

Multiplanar Displays

The last category of 3-D displays is multiplanar. Multiplanar methods are similar to the volumetric methods used in computer graphics, where the image is subdivided into *voxels*, or 3-D cubes (see "Voxels: Data in 3-D" on page 177). A multiplanar system divides an image into hundreds or thousands of planes (as in a CAT scan) and plots points on the image in each plane. To display the points on each plane, the system usually uses mirrors that reflect points produced by either a CRT or a laser. A possible disadvantage of such systems is that the images they produce are transparent, which can cause confusion when viewing images with high information content.

In the varifocal-mirror technique, you divide a 3-D scene into thousands of planes and have a point-plotting CRT plot one point from each plane. A circular mirror, vibrating at 30 Hz, reflects these points into your eye. The receptors in the eye have a temporal persistence that fuses the light emitted from the moving mirror to create the volume image. The Spacegraph varifocal mirror marketed by BB&N (Cambridge, MA) is an example of this type of system.

Such a system uses a directed-beam, calligraphic, or vector-type CRT with electrostatic rather than magnetic deflection, and it plots a point in less than 1 microsecond. The CRT requires a fast phosphor with short persistence to preclude image smear caused by the moving mirror. The P-46 green phosphor is the only phosphor that decays fast enough.

The mirror's vibration rate must be at least 30 Hz to prevent image flicker. The mirror is a flexible membrane or a flexing plate driven by a low-cost, low-frequency audio transducer (or woofer). The maximum diameter of the mirror is approximately 19 inches to avoid excessive noise and sympathetic vibrations in surrounding structures. The mirror excursion is about 0.4 centimeter. When the mirror is convex, the image distance from the mirror is 55.7 cm. When the mirror is concave, the image distance is 84.4 cm. Thus, the view-volume depth is 28.7 cm, which is approximately 72 times the excursion of the mirror (see figure 2).

Rotating Helix Mirror

The volumetric laser display developed by Garcia and Williams at Texas Instruments (Dallas, TX) operates on a principle similar to the one behind the varifocal-mirror technique. The multiplanar-display surface, a double-helix transparent display disk, rotates to fill the display cylinder (see the photo). The surface of the helical display disk rotates at 600 rpm, creating a cylindrical volume where 2-D images are fused by your eye. You can display images throughout the volume of the cylinder except for a small cylindrical space in the center of the volume. The display system uses a laser beam modulated to up to 10,000 Hz and synchronized with the displacement of the rotating disk. The disk is translucent, providing persistent 2-D slices that are fused by the viewer's eye to create volume 3-D images. The computer detects each rotation of the disk with an optical sensor on the shaft of the motor. The systems use a 36-inch diameter, 18-inch high volume display, with three colors and approximately 10,000 displayable points. The technology has the product name Omniview.

Omniview uses lasers because they provide for the use of multiple colors and very high resolution. It has the additional advantage of offering a display that can be made fairly large. As with the varifocal mirror, the image is transparent.

The Future

Of the types of 3-D displays available, stereo-pair technology is the easiest to implement, but it's not accessible to all people because of the occurrence of stereo blindness. Multiplanar technology overcomes this limitation, but it's limited by the transparency of the images it creates.

The goal of 3-D display R&D is to produce an interactive display system with no moving parts that can generate autostereoscopic, full-color, high-resolution, photographic-quality 3-D images, containing all the psychological depth cues, with the look-around property. Interactive holographic displays fit these criteria, but it isn't known if they will ever be a commercial reality. So the search for the ultimate display technology goes on. ■

David F. McAllister is a professor of computer science at North Carolina State University in Raleigh. His research interests include computer graphics, interactive 3-D technology, and curve-and-surface representation. You can reach him on BIX c/o "editors" and on Internet at dfm@adm.csc.ncsu.edu.

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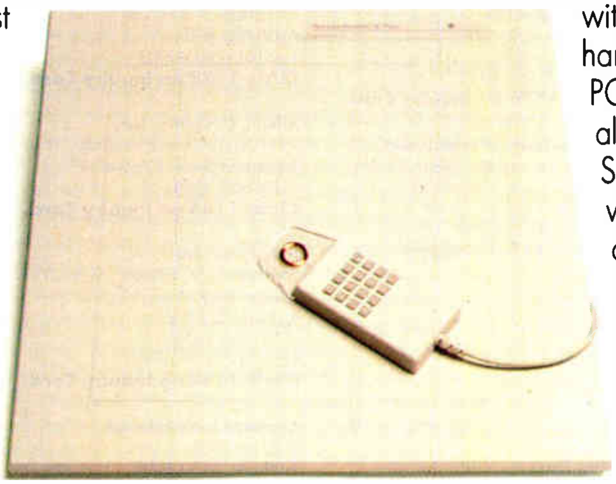

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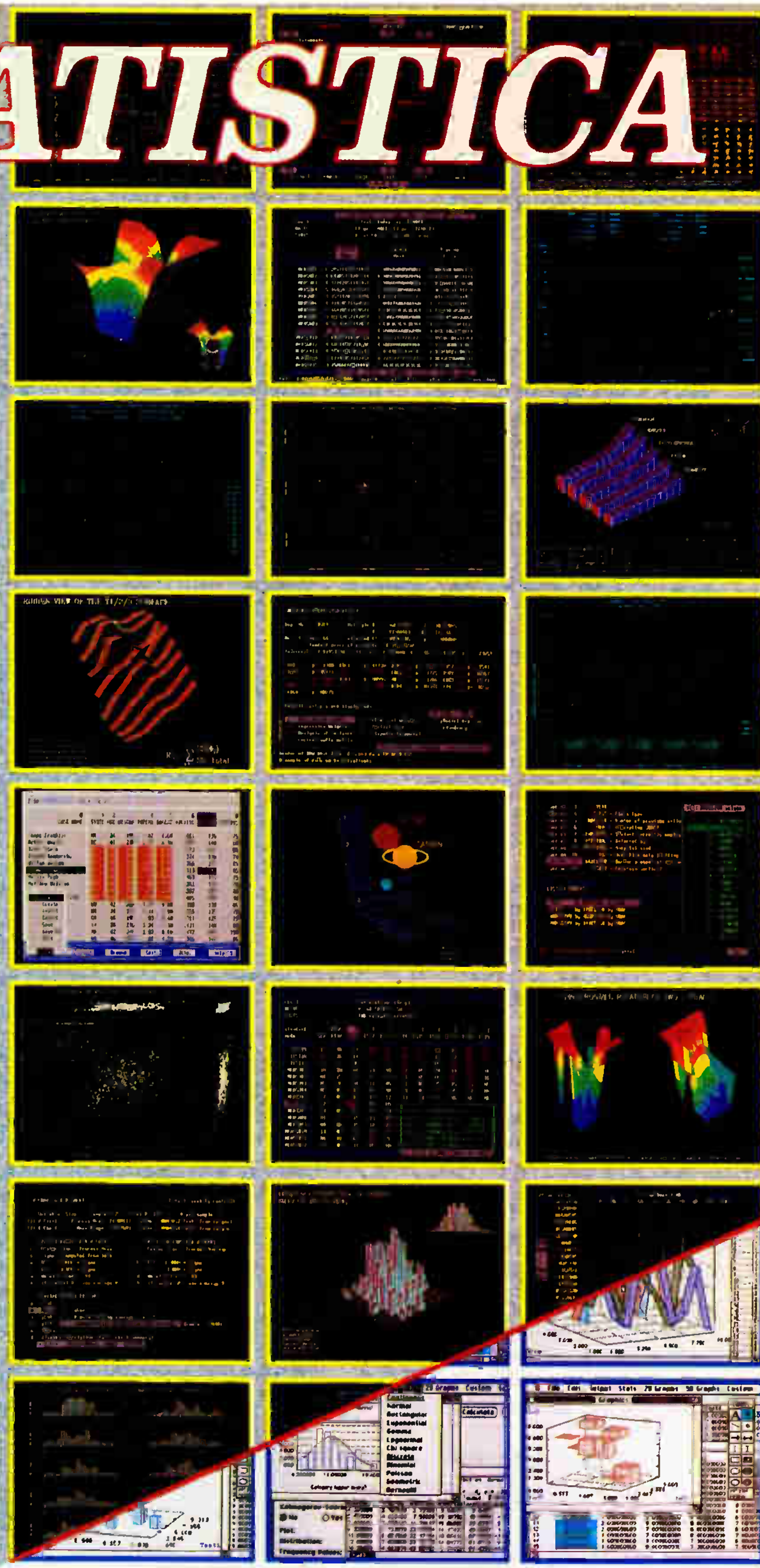

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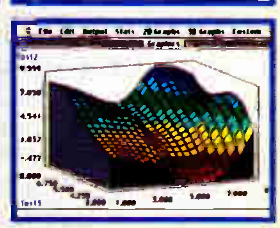

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Drawing from Experience

Howard Eglowstein

Choosing the right CAD system is a matter of matching the software to your particular needs. Your CAD department may have eight to 10 drafters working on designs with five or six drawings. Or maybe you've got a bigger crew, working three shifts and sending the finished part files directly to manufacturing. Or perhaps you need to put CAD on your engineers' desks. They won't be using it regularly, but when they do, they need something powerful and easy to use. CAD software can have hundreds of functions; if it's hard to use, it may also be hard for a casual user to remember all the commands.

Here's the situation Mike Baister, senior design engineer at Kodak's Office Imaging Division, found himself in: Kodak was using Unigraphics (a comprehensive minicomputer-based CAD system) software for everyday design and was running into problems. Training new users and handling daily support were a chore. Unigraphics systems can also run into big money—fast. "The cost of buying one Unigraphics workstation and a VAX or MicroVAX was so high that our smaller suppliers wouldn't go for it," Baister says. "That got us looking around for alternatives, and we couldn't recommend any alternatives that we didn't use ourselves."

What They Needed

"At Kodak," Baister continues, "we have another whole level of users aside from the everyday designers using CAD terminals. Engineers and technicians need to be able to walk up to a workstation, call up files, and review them for changes. If they're not regular CAD users, they never become fully CAD-literate. Management ended up spending horrendous amounts of money on people who simply didn't need that level of training."

The high cost of a Unigraphics workstation is prohibitive for many sites. "There's no way everyone will have one on their desktop," Baister says. "Those people using it on a casual basis share a walk-up terminal. In that environment, they could not just walk up, use it, and then walk away for two weeks. You just never learn the package fully. If you're planning to use CAD, you have to have a machine available to you at all times."

Trading Information

Besides affordability and availability, there's the issue of trading information with other applications. In the world of CAD, that means having accurate DXF and IGES file transfer. After looking at a couple of DOS and Mac packages, Kodak settled on Ashlar's Vellum. Baister found that "most of the problems [with PC CAD packages] were related to DOS—AUTOEXECs being eaten and so on. We wanted a Mac package and got our first copies of Vellum in 1990."

After two years, it's working out well. According to Baister, Vellum "really fits in well for new product development where you have a designer coming up with ideas for new concepts; it serves as a front end the engineers use for a finite-element analysis package. For stereo lithography, we need a 3-D shape to extrude. We use Vellum as a front end for the solid-modeling package. We use the Flatten View function a lot to take 3-D geometry and flatten it for all sorts of things. We have taken a trimetric view of a copier, squashed it flat, and sent the line drawing to an engraver to have plaques made for a sales presentation. Vellum is the only package we've found that lets you do that with a single button."

Compared to a minicomputer-based system, microcomputer-based CAD can be a big money-saver. "A single Unigraphics seat [hardware, software, maintenance, and support] costs the department about $3000 per month," Baister says. "The equivalent Vellum seat [a Mac IIci and a 19-inch monitor] costs about $130 per month."

Vellum has also found a home at Scaled Composites, an aircraft design firm headed by Burt Rutan. Rutan soared into aviation history when he flew the *Voyager* around the world non-stop in nine days back in 1986. After using VersaCAD for a while on the Mac, he switched to Vellum. Not only is it easier to work with, Rutan says, but it enables the casual users in the office to be productive as well.

Scaled Composites has 24 Macs, six PCs, and a couple of Apollo 570s for its 70 employees, and the Macs get most of the use. Is Vellum's lack of surface support a problem? "We don't need solid modeling," Rutan says. "We don't produce flowery-colored images for marketing purposes—most drawings are just quick how-to instructions for the shop. The most important thing for us is how long it takes to generate a model."

The Trouble with 3-D

The most popular package in the micro-CAD marketplace is AutoCAD. In one sense, while it's not really high-end CAD, it's at the high end of the spectrum in PC CAD software. Most users agree that while it's hard to use, it's a necessary evil and worth the trouble to learn it. Chris DeLucchi is president of the AutoCAD Users' Group of San Diego and author of *The AutoCAD Cookbook* series. "AutoCAD may not be the best out of the box, but it's very customizable and it's part of a large infrastructure—many third parties support it," he says. There are literally hundreds of add-on packages that will adapt AutoCAD to do just about anything you can imagine without doing any AutoLisp programming yourself. Other CAD

each software vendor to assign us an expert to guide us through the drawing. We also asked several professional designers about their preferences in 3-D CAD software; see the text box "Drawing from Experience," above, for their comments.

CAD software requires a powerful computer. We tested the Mac programs on an 8-MB Mac IIfx, an 8-MB Mac Quadra 900, and an 8-MB Mac II with a Radius Rocket accelerator. We tested the DOS programs on two different 486 PC clones (a 25-MHz and a 33-MHz), each with fast SCSI drives and 8 MB of RAM. The 33-MHz PC was equipped with various high-resolution graphics coprocessor boards. Most of the DOS packages ran well with a Number Nine GXi 34020 board in 1280- by 1024-pixel resolution on an NEC Technologies MultiSync 6FG 21-inch monitor. This combination was particularly effective. If you're just getting into PC-based CAD, we recommend this hardware configuration. Point Line packages have their own programming languages, but none enjoys the popularity AutoLisp has.

AutoCAD supports more platforms than any other package: PCs, Macs, and various Unix workstations. For 3-D, though, "moderately complex models bring all the midrange 3-D packages to their knees, including AutoCAD," says DeLucchi. Of all the PC packages available, why would someone prefer to use AutoCAD? "First, because of its customizability. Many think it's ugly and hard to use, but you can change it to stay out of your way and work with you. AutoCAD is a very endearing program. The second reason is infrastructure—user groups, books, magazines, dealers, schools, and availability of experienced operators."

Dave Sander is a senior design drafter currently working as a CAD consultant. "The most expensive part of getting a drawing out isn't the computer or the software, but what you pay the drafter—the time spent," he says. "Choose a package with the most effective interface for the job. That, and make sure you have enough computing power so that you're not always waiting for the computer."

Sander's advice? "Look at what your organization is currently doing. If it's simple projects and you're not communicating with other folks, you have the freedom to choose one of the low-end CAD systems. As your operation gets larger, ease of use is less important; you have more people using the software more regularly, and they tend to be more experienced. It's not a problem if they spend three months learning a system. The problem with 3-D is that people aren't trained to think in it. Drafting people have been trained for years in flat-paper representation. Even if you give them a 3-D system, they're still thinking in 2-D."

Howard Eglowstein is a BYTE Lab testing editor and active desktop publishing consultant who holds an S.B. in architecture and design from MIT. You can reach him on BIX as "heglowstein."

CADD didn't support the GXi, so we connected a 6FG to a Metheus Premier graphics card for that package.

For CAD, you'll want a 486/33 or a Mac IIci or better, a good graphics card, and the biggest monitor you can afford. A graphics tablet is a wonderful luxury, and for some users, it's a must.

AUTOCAD 386 RELEASE 11

AutoCAD's interface is starting to look outdated, but the program is one of the few that could draw the BYTE Pantheon without running into roadblocks.

In its 10 years, AutoCAD has set many industry standards for design and drafting on DOS computers. It is still entrenched as the most widely used and supported CAD application. With the most recent version, the $3500 release 11, Autodesk sells its Advanced Modeling Extension software as a $495 option to give AutoCAD the ability to perform 3-D solid-object modeling. AME is fully integrated with AutoCAD, and you can use the same set of commands for creating and manipulating solid objects. For more complex tasks, such as Boolean operations, dynamic and finite analysis, and interference detection, you need the AME commands. But whether you start with basic solid shapes or rotate and extrude 2-D objects, you can quickly produce shaded renderings and hidden-line views of your model.

To make AutoCAD do realistic, full-color models with lighting parameters and textures, you need the optional AutoShade extension ($500); version 2 of AutoShade gives you Pixar's RenderMan 3-D imaging technology for $500 more. This option lets you control surface characteristics, including opacity, texture, reflectivity, and an infinite number of light sources. You can import scanned images and apply them to surfaces as texture maps. You can also animate fully shaded models or generate animated walk-throughs of structures you've designed. With 24-bit color rendering and 16.7 million colors, you're limited only by hardware, memory, and imagination.

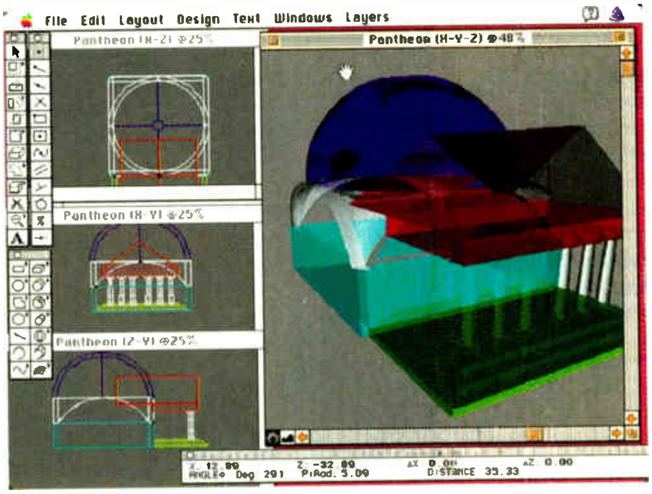
AutoCAD's open architecture gives it a flexibility that lets you customize it for different applications. This adaptability is one outstanding characteristic of the package. It has an embedded programming language, AutoLisp, and you can also run third-party AutoLisp application programs. With the AutoCAD Development System interface, you can work with high-level languages like C to further customize AutoCAD. The command structure allows for personal preference and flexibility, letting you choose commands from the menu on the right edge of the screen, the pull-down menu at the top of the screen, icon menus (available with certain screen drivers), tablet menus, and button menus.

The Pantheon model provided a rich ground for comparing the tools of the basic AutoCAD package and its AME software. The building's columns should contain 25 flutes, or rotational divisions. With the AME solid-modeling approach, we could create only 24 flutes, but with the basic AutoCAD commands, we could draw all 25 flutes. The Coons patch (a complex surface mesh represented by a series of nodes, or points, that could have been used to create the pendentives that support the dome) would not show the intersection of the pendentives and the portico. We therefore elected to use solid modeling to create a sphere and did Boolean subtraction operations to slice off the sphere at the building's sides.

AutoCAD won't let you truly wrap text, such as our motto, around a curved object (the dome) so that it lies flat. We managed to achieve a close approximation by using an array copy of a character along a curved path and then replacing each character field with the desired text.

AutoCAD can run in a single- or dual-monitor configuration (the second monitor displays the command line and command menus), and it performed well with the Number Nine display board. In 32-bit protected mode, AutoCAD uses the virtual memory manager to directly access all the memory in your machine without using expanded memory. AutoCAD is also compatible with most PC-based networks and server authorization.

continued



DESIGNCAD FOR THE MAC 3.0.1

The basic DesignCAD screen splits into four parts: top, side, front, and perspective views.

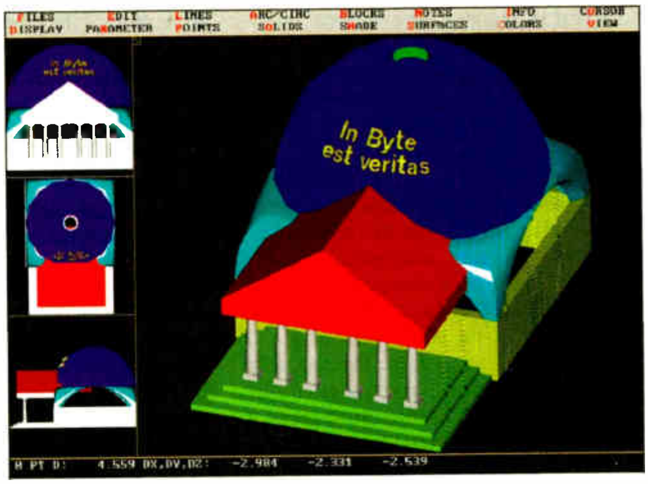
Proving that a CAD package can let you draw a bank building without emptying your bank account, the Mac version of DesignCAD 3-D sells for just $300, yet it does just about everything the bigger guys do. For this low price, you get 3-D drawing, shading, symbol libraries, surfaces, animation, and multiview editing. This is all the capability many designers will ever need. Its price/performance ratio makes it a package we must recommend.

The basic DesignCAD screen splits into four parts: top, side, front, and perspective views. Putting in the Pantheon steps was trivial once we figured out the coordinate system. When you think of a 2-D drawing, you usually envision the axes as *x,y* with (0,0) at the bottom left, positive *x* values to the right, and positive *y* values going straight ahead. When you switch to three dimensions, you pile up an infinite number of *x,y* planes, going up along the *z* axis. Thus, the top view of a 3-D model will be *x* and *y*, the front view will be *x* and *z*, and the side view will be *y* and *z*. A good package lets you select your own system, but we expect the standard *x,y* top view as a default.

DesignCAD, however, calls the top view *x,z* and relabels the other views accordingly. With the model skewed 90 degrees, mapping the Pantheon into DesignCAD's space took a bit of mental gymnastics. The company is looking at offering user-selected coordinate systems in a future release. Another limitation is that, like other packages, DesignCAD does all its drawing in a construction plane. Depending on the view, you enter a pair of coordinates for each point and DesignCAD adds the third dimension. Unlike other packages, DesignCAD insists on putting the third dimension in the model's origin. That became a constant source of trouble during construction of the Pantheon. To create the columns, we had to draw them around the model axis, revolve them around the axis, and *then* move them to the correct location. Competing packages let you select arbitrary construction planes and revolution axes, critical factors for complicated models.

Connecting the surfaces on the dome support turned out to be the trickiest part, and despite numerous attempts, we never succeeded in getting the program to work perfectly. Everything else was a breeze. DesignCAD made short work of getting the basic Pantheon in place, and we were impressed by the software's ease of use and general performance. With the finished Pantheon on-screen, it took nothing more than a mouse-click to bring up a Gouraud-shaded rendering, complete with highlights. If you want something fancier, DesignCAD exports to RenderMan (RIB) format, where you can develop a photo-realistic image.

DesignCAD also includes external functions for importing and exporting DXF and IGES file formats. Unfortunately, we weren't able to get either format to import or export properly. At worst, the files were unreadable, and at best, the elements that made it through the conversion were rotated because of the weird coordinate system. If you're thinking of switching your CAD shop to DesignCAD, be sure first to take a close look at the program's file conversions.



DESIGNCAD 3-D 4.0

DesignCAD 3-D offers three different perspectives and a large 3-D drawing area that provides simultaneous views of the drawing. Each view tracks the dynamic 3-D cursor, which can be forced to move in the x, y, *or* z *direction.*

The strengths of DesignCAD 3-D's DOS version are ease of use, powerful solid-object modeling, and price. What struck us immediately were the three viewports (i.e., construction windows) with different perspectives and the large 3-D drawing area that gives simultaneous multiple views of the drawing. Each view tracks the dynamic 3-D cursor, which can be forced to move in the *x*, *y*, or *z* direction. The program will let you set points in nine different ways, either before or after a command. You can create objects via a command-line interface, by using single-keystroke commands, or by clicking on commands in menus with the mouse.

As with any 3-D modeling program, you want to be able to view your drawing or model from any angle or perspective. DesignCAD has mastered this technique with a dynamic view operation that uses a simple cube representing your model; you can manipulate its orientation to the world plane by moving the mouse in any direction and change the perspective with the + and − keys.

DesignCAD handled our Pantheon model easily and with efficient keystroke and command input. We drew the pendentives using arcs, surface commands,

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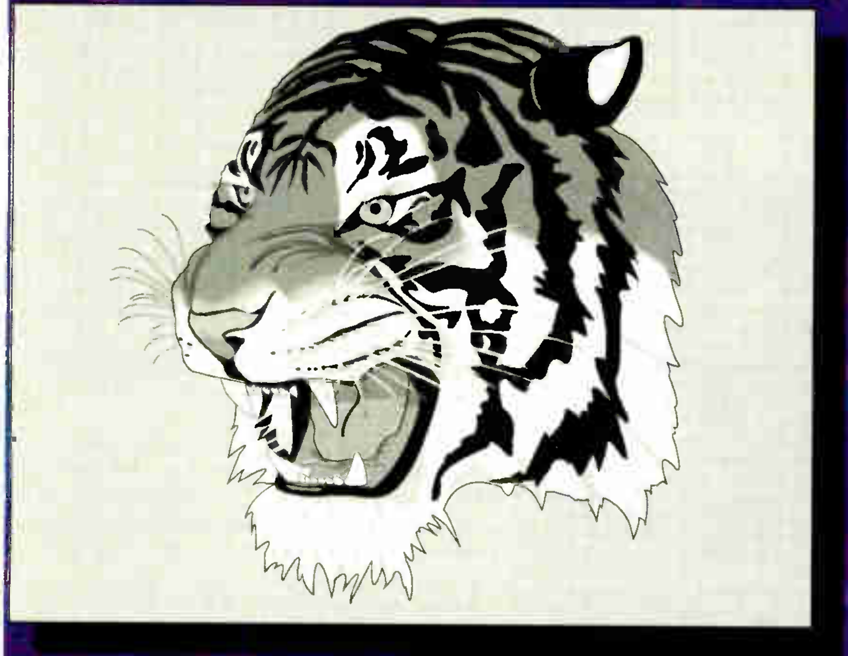

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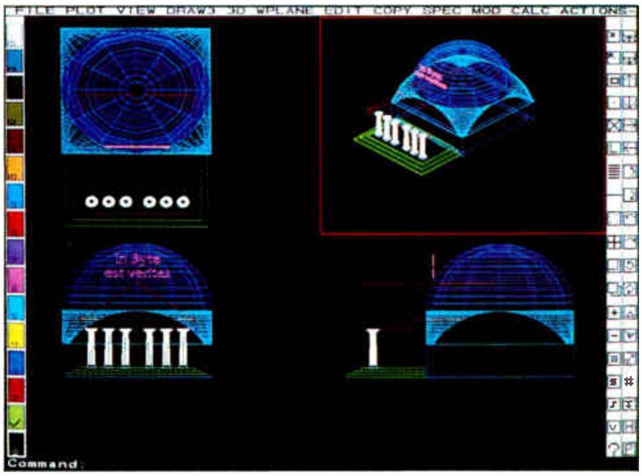
a mirror command, and other common construction commands. To inscribe the text, we used a vector option that enabled us to extrude the text. Text always lies on a single plane, but it is possible to write a BasicCAD program to produce text that wraps around a curved surface.

Some solid operations that DesignCAD handles and AutoCAD 386 does not include surface area calculations of a specific plane or face, interference checking, solid corner fillets, and automatic 3-D wall construction. DesignCAD can do shading and hidden-line removal on any or all views. With its control of light intensity and provision for eight different light sources, the program will let you do some nice enhancements of a drawing like the Pantheon. DesignCAD can plot shaded drawings, which some CAD programs cannot do, and save raster screen images in the PCX format. You can also sequence drawing files of models with a key-frame animator to generate a slide show.

This is an impressive package for the price: only $499. DesignCAD doesn't require you to go out and buy expanded memory (although it does support it), a math coprocessor, a mouse or digitizer, or an expensive display adapter or monitor. It incorporates auto-dimensioning and macro capabilities, and it can be customized with the built-in BasicCAD programming language. Kudos to a professional CAD package that can produce complete 3-D models for less money than you'd pay for most other applications available today.

FASTCAD 3D 2.72

One big difference between FastCAD and other PC CAD programs is in the way it creates surfaces or solids like domes, Coons patches, and cylinders; these are true 3-D algorithmic surfaces, not just 3-D faces or polygons and mesh surfaces.



Written in assembly code, FastCAD 3D is fast indeed. Redrawing and hidden-line removal are particularly quick. One big difference between FastCAD and other PC CAD programs is in the way it creates surfaces or solids like domes, Coons patches, and cylinders; these are true 3-D algorithmic surfaces, not just 3-D faces or polygons and mesh surfaces. This approach greatly reduces the file size of the entity in memory space. FastCAD's designers distinguish between these solids (i.e., entities made up of many polygonal sides in 3-D space), solid-object modeling, and 3-D polygons, which can have up to 45 nodes and be extruded into a "solid" entity.

The package includes FastCAD 2D, a subset of the 3-D program that runs faster, and FastCAD RenderMan, which you need to produce photo-realistic renderings. A word of caution, however: If you intend to install any display card other than those listed as supported, don't try it. You might be able to load the program and do some basic modeling, but more complex constructions, such as Coons patches, could run into distortion problems. (The program ran better with the Orchid ProDesigner II than the Number Nine GXi we were using for most of the other applications.)

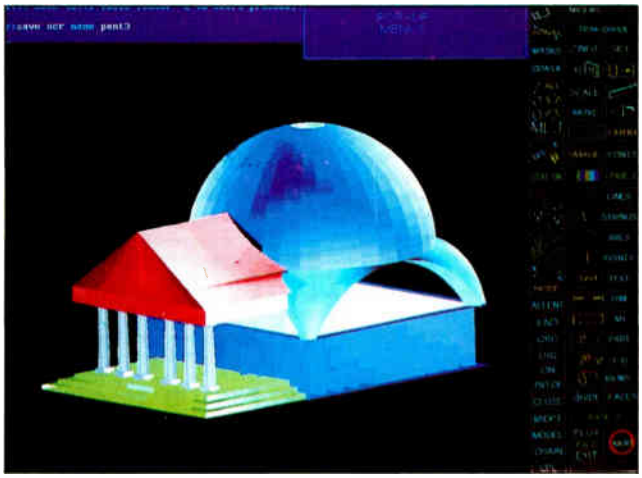
Drawing the Pantheon itself was fairly straightforward and quite fast, taking fewer steps than most other applications we tested. FastCAD does not come with outline fonts that can be extruded, but it can import DXF files generated by programs like CorelDraw, which can then be extruded. While the program can import and export DXF files, it cannot translate IGES files, which could be a big limitation in some shops.

One thing about the program's interface bothered us. The vertical toolbox of icons for views, layers, line styles, and fill styles is a nice idea, but on some displays it's hard to distinguish the icons.

FastCAD is very capable and competitive. If you don't have the time to wait for renderings of 3-D models, consider this one. The price for the speed is $2995.

PERSONAL DESIGNER 5.01

Personal Designer's command-line interface blends nicely with the digitizer/menu interface. The menus essentially squirt commands into the command line.



This $3995 PC program comes from Computervision, a company deeply rooted in the history of CAD. We expected the package to do the job, and it didn't let us down. It was touch and go at first, though. The copy protection made installation a bit tricky, and the printer-port device lock wouldn't allow for reliable printing once it was installed. With the company's help, we bypassed the setup procedures and manually installed the device on LPT2 (unused on this machine). It was smooth sailing from there.

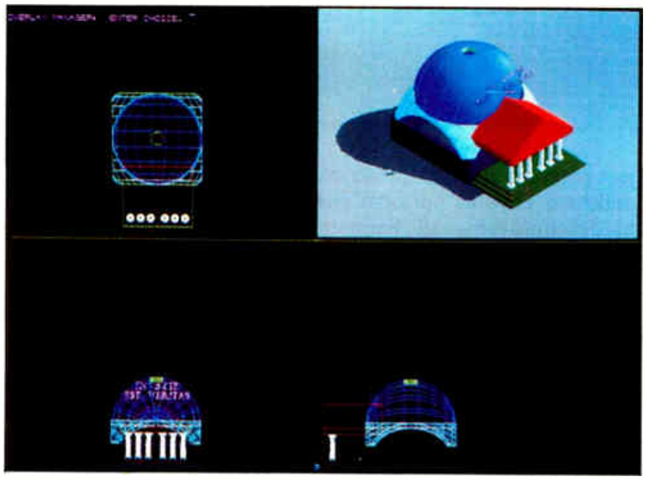
The basic interface in Personal Designer is the command line, and the manual explains each of the many commands. The command line is the preferred interface for some professional drafters (it's also the preferred interface in most AutoCAD shops), while others would rather never touch the keyboard. If you don't like keyboards for CAD work, stay clear of PD.

At the very least, the syntax is consistent from command to command. At any time, you can switch from keyboard to digitizer entry and apply a number of powerful selection modifiers to a data point. Drawing the Pantheon was slow going at first, and without the company's expert help, we might have struggled with the manual for days without getting anywhere. With expert assistance, we quickly figured out the interface and got through the drawing in less than average time.

PD has no built-in file-export capability and has a limited ASCII file-import function. Computervision offers format translators for graphics import and export. If you make the switch to PD, plan to convert everyone in your shop, as you won't be able to move drawings smoothly to and from a PD environment. We ran the program on a 486/25 with an Orchid ProDesigner II Super VGA card. PD supports a wide variety of display cards, but its ProDesigner driver was a bit buggy. Nothing terrible—just a few stray lines and sloppy screen updates. For serious work you'll want a bigger, faster display card anyway, but do check the software with your intended hardware.

PD is not for casual users. To get real work done, you'll have to master the command language completely, and that probably means using it regularly. If your job requires only occasional CAD use, you'll probably forget this package as fast as you learned it.

POINT LINE CADD PROFESSIONAL 7.52e



Point Line CADD is a very capable package, with advanced operations like animated walk-throughs. Here, the Pantheon is shown in one viewing area, while different perspectives are shown in other windows.

At $5000, Point Line CADD Professional is the most expensive CAD package we looked at. But behind the price tag are some sophisticated capabilities, such as recording animated walk-throughs and fly-throughs directly to videotape. With interframe interpolation smoothing for realistic motion, the program will play back animations at up to 60 frames per second on an ordinary VCR and TV. The Professional package also includes the company's 2D Design and Drafting program and the Professional Paint program, which can import AutoCAD slide and AutoShade rendering files, as well as Targa files.

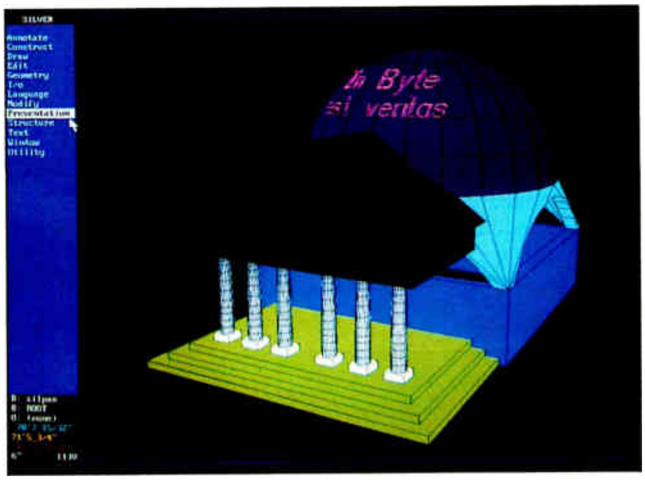
We had some trouble getting this program to run with our test machines. Initially, we tried it with a Metheus UGA 1228 graphics card at 1280 by 1024 pixels and 256 colors and a high-resolution dual-monitor setup. After several attempts at reinstalling drivers and making other changes, and with technical support from Point Line, we determined that it was a mysterious problem at best. Persistence paid off, however. Changing to a Metheus Premier VESA-compatible board, a single VGA monitor, and a different mouse and driver solved the problem. Point Line CADD appears not to like the Microsoft Mouse driver.

Unfortunately, the single-monitor setup overlays the command-menu box on the drawing area, creating a very confusing array of dimmed text and lines. You can, however, toggle this menu box off and on; when it's off, you still have the command line at the top of the screen, with no options to choose from. Coordinate entry was a bit nerve-wracking at first as we tried to navigate in the compressed VGA environment. Running the high-resolution monitor and a VGA monitor in a dual-monitor setup would eliminate this problem.

continued

Nevertheless, we were able to create the Pantheon without a hitch, and in the process we discovered a very ingenious mechanism on-screen. In the upper right window, the program can display a small rendered 3-D model complete with light source and ground shadows (surface geometry cannot be shadowed, however). You can change the perspective and switch from solid to wireframe.

Point Line claims to be the first company to fully integrate 2-D and 3-D CAD on the PC, the first to do walk-through and fly-through animation, the first to integrate solid modeling for PCs, and the first to implement RenderMan on the PC. So why haven't we heard more about Point Line CADD? Although the program is extremely capable, we couldn't help but wonder if our mysterious installation problems might have something to do with the package's lack of visibility. Stay tuned as this contender makes the challenge.



SILVER-SCREEN III PROFESSIONAL EDITION 3.01

SilverScreen III's windowing capabilities are more than adequate for drafters who need multiple interactive simultaneous views of a model. You can display as many as nine windows at once.

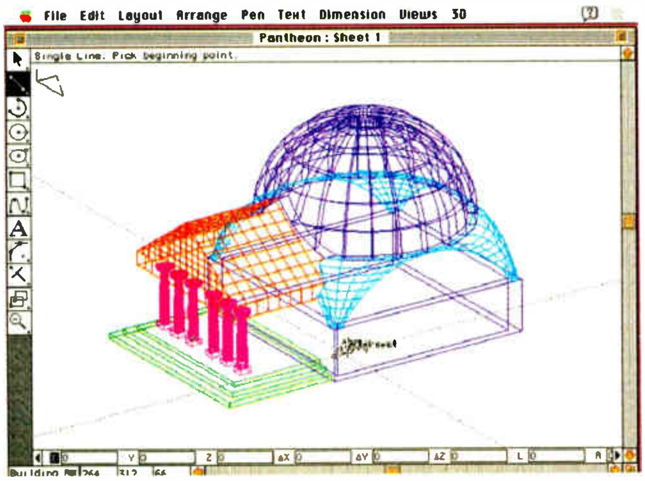
If you have ever fantasized taking a walk through a 3-D drawing of a building you've made, this is one program to consider for its "video slide show" effects. With a "camera," you can record snapshots of the drawing from an infinite number of angles and perspectives inside and outside your model. Later, you can enhance the drawings with shading and other lighting characteristics.

Schroff Development's SilverScreen III is a true 3-D solid-modeling program. It uses an object-oriented hierarchical drawing structure based on a 3-D database. The program's approach to object creation in a 3-D construction space makes it easy to perform shading and hidden-line removal. Even though the command-menu box and status area occupy one-sixth of the screen area, the windowing capabilities are more than adequate for the drafter who needs multiple interactive simultaneous views of a model. You can have as many as nine windows displayed at once, showing oblique, axial, face, and isometric views. Pressing a hot key will change the view.

To draw the Pantheon, SilverScreen III does some things in a different way than other CAD programs. Instead of generating a complete sphere and then cutting it in half, SilverScreen III sweeps an arc. A Boolean difference operation subtracts a cylinder from the dome to create the oculus. For the text around the dome, the program extrudes the letters out to a construction sphere and then trims them in order to create the 3-D relief effect.

SilverScreen III handles entities in a unique way. It uses an object-oriented database, and instead of layers, it uses a tree-structured system. Entities have path names, just as in a DOS or Unix file system. Each entity has its own entity space and axes of rotation. Thus, you can rotate an entity about its own axes without having to first align it with construction space.

The built-in Silver C compiler provides the ability to customize mouse control of objects so that you can animate them in axial relations, as well as customize menus and script command files. You can use the language to automatically generate scripts by recording sequences of modeling commands. (In fact, the developers at Schroff sent us a script file detailing the steps they used to draw the BYTE Pantheon.) One thing that SilverScreen III doesn't have is built-in photo-realistic rendering tools; to achieve those sorts of effects, you need the RenderMan interface that Schroff adds to the $2995 package for another $2000.



VELLUM 3D 2.0

Vellum 3D's Drafting Assistant provides a friendly interface, but the program's surface tools generate lines, not continuous surfaces.

A $2495 Mac program, Vellum 3D is the only package in this review that we found fun to use. (Ashlar has 2-D versions for Windows and Silicon Graphics machines, with 3-D ports scheduled for release soon.) Vellum 3D's interface is unique, but the program performs similarly to other full-featured 3-D drafting packages. Well, almost. Vellum 3D doesn't support surfaces, but instead treats your drawing as a wireframe image. Vellum's surface tools generate a series of lines, not a continuous surface. For some applications this is a serious omission. Too bad, as Vellum's friendly front end has to be seen to be believed.

The basis of Vellum's interface is the Drafting Assistant. As you move the

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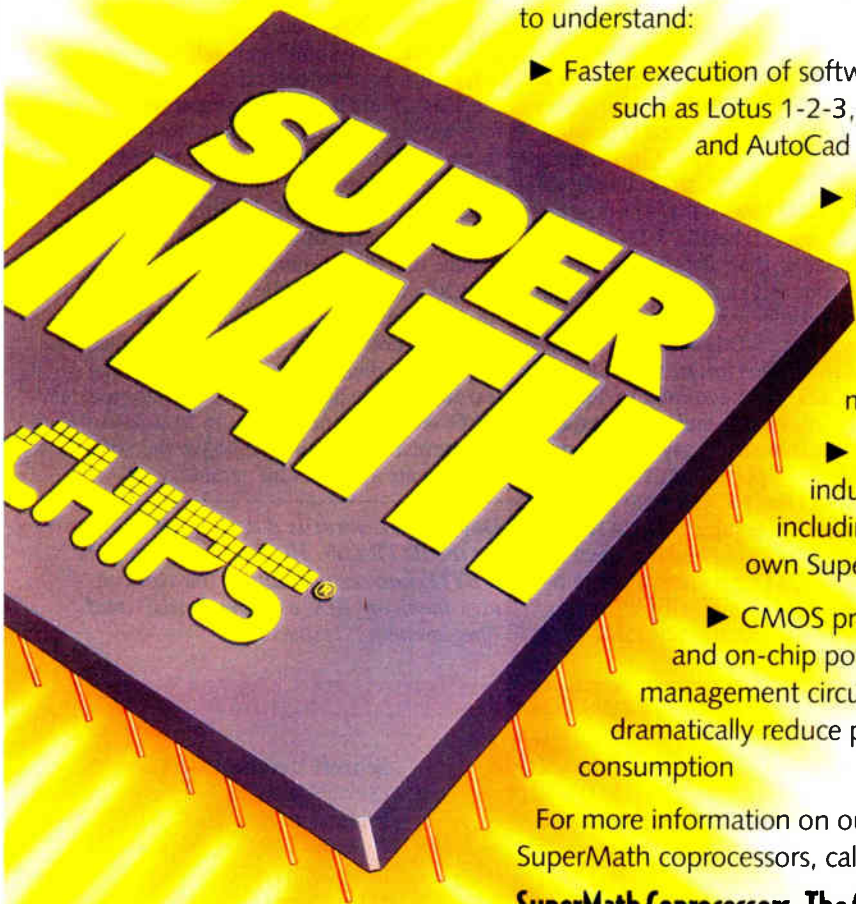

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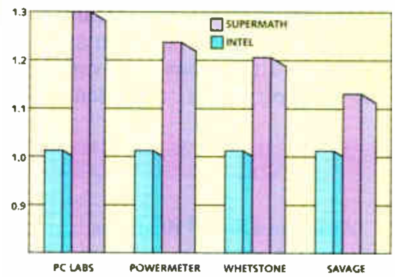

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cursor around the screen, the program constantly checks its position against any nearby data point and alerts you to any interesting geometry. As you approach the end of the line, the cursor snaps to the endpoint and shows you exactly where it is. If that point creates an intersection with another line, you'll see that, too. Likewise, you will instantly know about the centers of arcs, tangent points on lines, midpoints, and so on.

We started the Pantheon by typing in the size of the steps, but as the drawing went on, the Drafting Assistant automatically made the columns revolve around their own centers and made the dome snap to its base. To make the simulated surfaces, we had to trick Vellum into generating a mesh by breaking a line up into discreet segments before revolving it. That created a serious problem with the columns. The basic procedure was to create a profile of the column: essentially, a straight line, a gentle curve, and an arc connected at their endpoints. Pretty easy, and by switching to a top view, creating the column with the Revolve menu choice was trivial.

To get the simulated surface, though, we broke the profile into 11 pieces and created 25 segments radially during the revolve. The results looked great but created 550 separate lines in the drawing. Six columns like that (over 3000 lines) proved taxing for the Mac IIfx. Real surfaces would have been better.

We didn't investigate Vellum's parametric capabilities. You can specify an element's dimensions as a variable, relate geometry to it, and then vary the drawing by simply changing the variable. The whole drawing updates, allowing you to customize and resize parts very easily. Even better, the Movie feature lets you program in a stepped series of parametric values, generate each drawing, and capture the frames as real-time animation. Being able to draw complex systems with parametrics and animate them through their range of motion could save you untold hours of redesign time.

Our Favorites

The best way to choose a CAD system is to try the software to see if it can deal with the types of designs you work with and then buy the hardware it requires. Given the cost of having a senior designer waste untold hours with the wrong CAD package, you'll be better off tossing out that old machine and getting a new one.

One lesson we've learned in working with CAD packages is this: Don't assume you have to have 3-D CAD. Just because a package is labeled "3-D" doesn't mean it's better than 2-D programs or it'll make your job easier. Many designers do very serious work with 2-D CAD.

In many cases, 3-D is overkill. For example, Interactive Design Consultants' Anvil-1000MD has been used to develop cotton pickers, buses, and weapons systems. In fact, some users say that for anything other than photo-realistic renderings they don't need a 3-D program.

Those who do require 3-D CAD have some viable choices. Drawing the Pantheon in AutoCAD was quite a chore because of the sheer complexity of the command structure and the obtuse syntax, but in the end, it was one of the few products that made it all the way through the drawing without any significant roadblocks. You should also consider the wealth of third-party support in hardware and software for AutoCAD, the big community of AutoCAD users, and the availability of temporary help trained in its operation. Add all that up, and you'll see why many firms choose AutoCAD.

Personal Designer has many of these attributes, but since it carries the same price as AutoCAD and is no easier to use, we don't think it has any clear advantage over AutoCAD. We liked DesignCAD as a PC product because it's easy to use and has a dynamic 3-D cursor that tracks all four viewports simultaneously. For the price, it's hard to beat. DesignCAD on the Mac should have been a clear winner, too, but its insistence on drawing everything in the origin plane was a real pain. FastCAD's tool set made our model practically draw itself, but it wasn't our favorite because of the low-key user interface that didn't match up to its speed.

While it didn't handle the surfaces our model required, we fell in love with Vellum 3D. For casual users, the interface (especially the Drafting Assistant) is just too clever to be believed. Even weathered CAD veterans find it simpler to point to an interesting location and have the software locate any relevant geometry. ■

David L. Edwards is a consulting editor for the BYTE Lab. Howard Eglowstein is a BYTE Lab testing editor. You can contact them on BIX as "dedwards" and "heglowstein," respectively.

COMPANY INFORMATION

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Pryor, OK 74361
(918) 825-4844
fax: (918) 825-6359
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Ashlar, Inc.
(Vellum 3D 2.0)
1290 Oakmead Pkwy., Suite 218
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(408) 746-1800
fax: (408) 746-0749
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Autodesk, Inc.
(AutoCAD 386 release 11)
2320 Marinship Way
Sausalito, CA 94965
(800) 445-5415
(415) 332-2344
fax: (415) 331-8093
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Computervision
(Personal Designer 5.01)
100 Crosby Dr.
Bedford, MA 01730
(617) 275-1800
Circle 1318 on Inquiry Card.

Evolution Computing
(FastCAD 3D 2.72)
437 South 48th St., Suite 106
Tempe, AZ 85281
(800) 874-4028
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Point Line U.S.A.
(Point Line CADD Professional 7.52e)
1636 Wilshire Blvd., Suite 200
Los Angeles, CA 90017
(213) 353-1480
fax: (213) 353-1483
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Schroff Development Corp.
(SilverScreen III Professional Edition 3.01)
P.O. Box 1334
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MONITORS: Beyond VGA

The BYTE Lab tests 24 high-resolution color monitors for PCs and the Mac and tells how to choose the display that best fits your needs

RAYMOND GA CÔTÉ AND STANFORD DIEHL

It has been a long time coming, but the lowly monitor finally is getting its due. These days, with so many important applications built on graphical user interfaces, a high-quality monitor not only can make your work more pleasant, it can make you more productive, as well. To help you decide whether the time is right to upgrade your Mac or PC display, this month the BYTE Lab reviews 24 color monitors that give your eyes something to look forward to: higher resolution and a noninterlaced display that reduces flicker by updating every line on the screen each time the screen is refreshed. Many of the models are comparatively easy on the budget, too. The two dozen 13-inch to 17-inch models we examine carry list prices ranging from $649 to $2699, but half retail for $1200 or less.

The more closely you look at color monitors, however, the more questions you'll find to consider. How big is big enough? Is VGA resolution adequate or do you want to tap resolutions beyond 640 by 480 pixels? What does multiscanning capability buy you? How do you evaluate image quality objectively? Our review provides important tools for resolving these issues and selecting the display that's right for your graphical applications.

You can cover a lot of ground by checking features and evaluating the specifications listed in the table "High-Resolution Monitors Compared" on page 214, but many of the problems you're likely to encounter aren't addressed in manufacturers' specs. To locate potential trouble spots and pick the best overall display, the BYTE Lab conducted a comprehensive set of objective tests on all 24 monitors. We recorded over 300 readings for each monitor, measuring such variables as luminance, line width, convergence, jitter, and swim. Our test setup consisted of an AT-class computer with an ATI Technologies VGA Wonder XL 1024- by 768-pixel graphics card. We collected test data using a Microvision Superspot 100 monitor evaluation system. The Superspot system consists of controlling software and a charge coupled device array for measuring line width and regularity.

Used with the list of monitor features, our test results will help you compare one monitor against another. Even so, you should take a good look at a monitor before purchasing it, and if possible, fire up some graphical applications. Ideally, you also should connect the monitor to the display card you will use with it. DisplayMate, a $149 software package from Sonera Technologies (Rumson, NJ), provides an excellent set of simple tests for evaluating the quality of a display. The program fits on a

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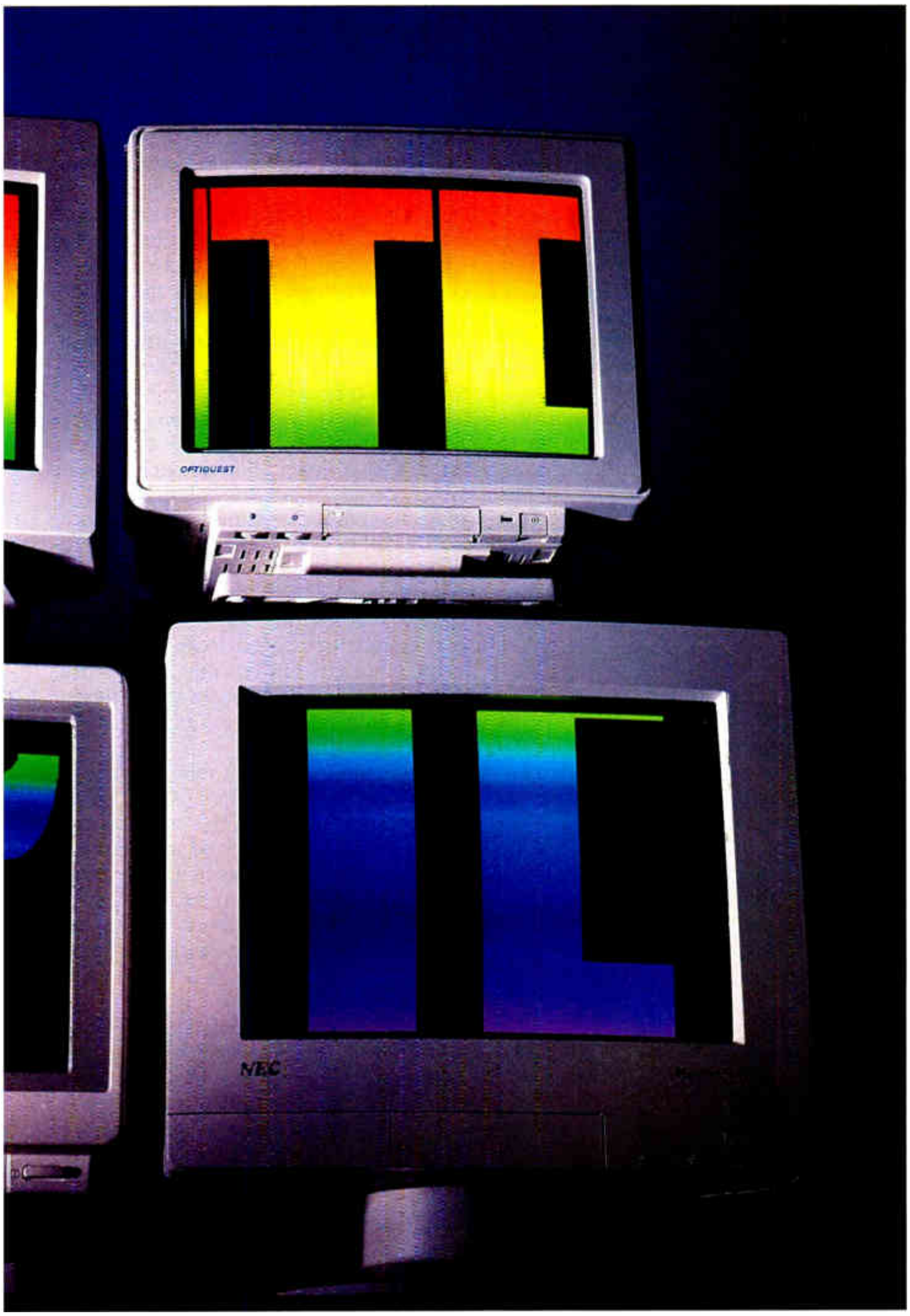


single disk, so you can bring it with you when you shop.

Beyond VGA

In 1987 when IBM introduced VGA as a standard component for its new line of PS/2 computers, it revolutionized the market for color displays. Finally, a video standard offered the color and resolution necessary to bring graphical applications to the desktop. But although the market has seen a number of advancements in resolution and color, no single new video standard has emerged in the five years since the introduction of VGA.

The most prominent standards body, the Video Electronics Standards Association (VESA) has cleared up some of the confusion by endorsing two basic specifications beyond VGA: Super VGA (800-by-600 resolution with 16 to 256 colors) and high-resolution VGA (1024-by-768 resolution with 16 to 256 colors). Many vendors now offer display systems conforming to the resolution guidelines of the VESA standards. Despite this, different scan rates, custom video drivers, and other deviations make the move beyond VGA a tricky one.

To avoid compatibility headaches, you need to consider a monitor as but one-half the picture. If you already have a video display card, look for a monitor that works well with that card. If you're

BYTE ACTION SUMMARY

- **WHAT NONINTERLACED, 1024- BY 768-PIXEL COLOR MONITORS DO**
  All update each line of the screen each time it is refreshed and are capable of displaying a 1024- by 768-pixel image.

- **LIKES**
  Image quality and performance are continually improving. Many of these monitors also are designed to work with recent model Macintosh computers.

- **DISLIKES**
  Hefty prices and, in some cases, considerable weight. Some monitors are so heavy their manufacturers warn against placing them on top of your computer.

- **RECOMMENDATIONS**
  The 17-inch ViewSonic 7 combines cost and performance leadership.

starting from scratch, carefully evaluate both pieces of the equation, perhaps buying the best monitor you can find and then picking the display card that works best with that display. Whatever your strategy, remember that if you want to achieve high-quality images, the display card and the monitor you choose must work together.

Think Big, Think High

When you start shopping for a monitor, consider screen size and resolution first. The two are closely related. A large screen allows you to run applications at high resolutions. While some smaller screens can accommodate resolutions beyond the VGA standard of 640 by 480 pixels, you'd best add your optometrist's bill into the cost of the monitor. Screen characters shrink each time you boost screen resolution. At 1024- by 768-pixel resolution, characters are barely readable on a 13-inch screen. For resolutions that high, a 15-inch screen really is the minimum you should consider. A good rule of thumb is to divide the horizontal resolution (640 for VGA) by the horizontal width of the screen. This gives you a pixels-per-inch measurement. You'll find yourself squinting at displays containing more than 80 pixels per inch.

High resolutions buy you more on-screen real estate to work with. If you rely on multiple windows for multitasking applications, the added space will make you more productive. Large screens may well improve productivity further because they typically make the images on-screen more readable. Precise work, such as desktop publishing, technical illustration, and CAD, requires high resolutions and an ample screen.

Manufacturers measure a monitor's screen size diagonally, from corner to corner, but you should confirm the accuracy of this measurement before buying. Some plastic bezels surrounding the face of the monitor take up more screen area than others, so not all 16-inch monitors offer the same viewing area. Carry a tape measure and make sure you're getting what's advertised.

The Smaller, the Better

The next specification to consider is the monitor's *dot pitch* measurement. To understand dot pitch and a few other technical specifications, you need to have a basic understanding of how a monitor works. On a color monitor, images are made up of tiny red, blue, and green phosphor dots. Usually, three electron beams (one each for red, green, and blue) paint an image by sweeping across the inside of your monitor's screen and exciting the phosphor dots. The image is painted a line at a time, from left to right and from top to bottom. A monitor's dot pitch is the distance, in millimeters, that separates each of the phosphor dots. The smaller the number, the finer the image. Look for a monitor with a dot pitch of no greater than 0.31 mm. All the monitors in this review fall in this range.

Unfortunately, evaluating image quality is not as simple as finding a monitor with the lowest dot pitch. Factors such as *convergence* and *blooming* also come into play. A monitor with poor convergence will display white characters fringed with color and other distracting effects caused by poor registration of color. To create pure colors, the three electron beams must be aligned so that they converge precisely. Serious misconvergence will make your screen seem out of focus, and no amount of manual adjustment of the controls will help.

Some monitors cannot maintain image quality at high intensities. As intensity increases, the image begins to break up. Characters become blurred and unreadable. To some extent, this blooming effect is unavoidable, but severe blooming may reveal defects in a monitor's design and undoubtedly will prove annoying.

Emission Control

Several years ago, people began to voice concerns regarding possible health hazards resulting from magnetic emissions of video monitors, as well as from other equipment such as power lines and electric appliances. (See "Of Monitors and Emissions" Under the Hood, September 1990 BYTE, page 445).

In 1988, a Swedish commission adopted a standard for measuring electrostatic, electric, and magnetic alternating fields. In July of 1990, a new set of Swedish standards was issued to cover only very low frequency (VLF) emissions. In December 1990, yet another set of Swedish guidelines, MPR II, was promulgated to cover both magnetic fields of extremely low frequency (ELF) and VLF fields; it eventually was expanded to include alternating electric fields and electrostatic emissions.

Today, many monitor vendors adhere to the stringent Swedish standards, but not all manufacturers comply. Of the 24 monitors the BYTE Lab reviews, more than half meet the Swedish MPR II emission standards. Those that don't include: Aamazing Technologies' CM8486X, Amdek's AM1817, AOC's CM-337, Idek/Ilyama's MF-5217, Relisys' RE1422, Sampo's KDM-1466, Samsung's P17CM and SyncMaster 15, Seiko's CM1450 14, and Tatung's CM14UAS and CM17MBD.

But as time goes on, compliance with MPR II is likely to increase steadily. Louis Slesin, publisher of the New York-based *VDT News* newsletter, expects all monitor manufacturers eventually will market monitors that conform to the MPR II standards. Says Slesin: "It only costs a little more to build a low-emission terminal."

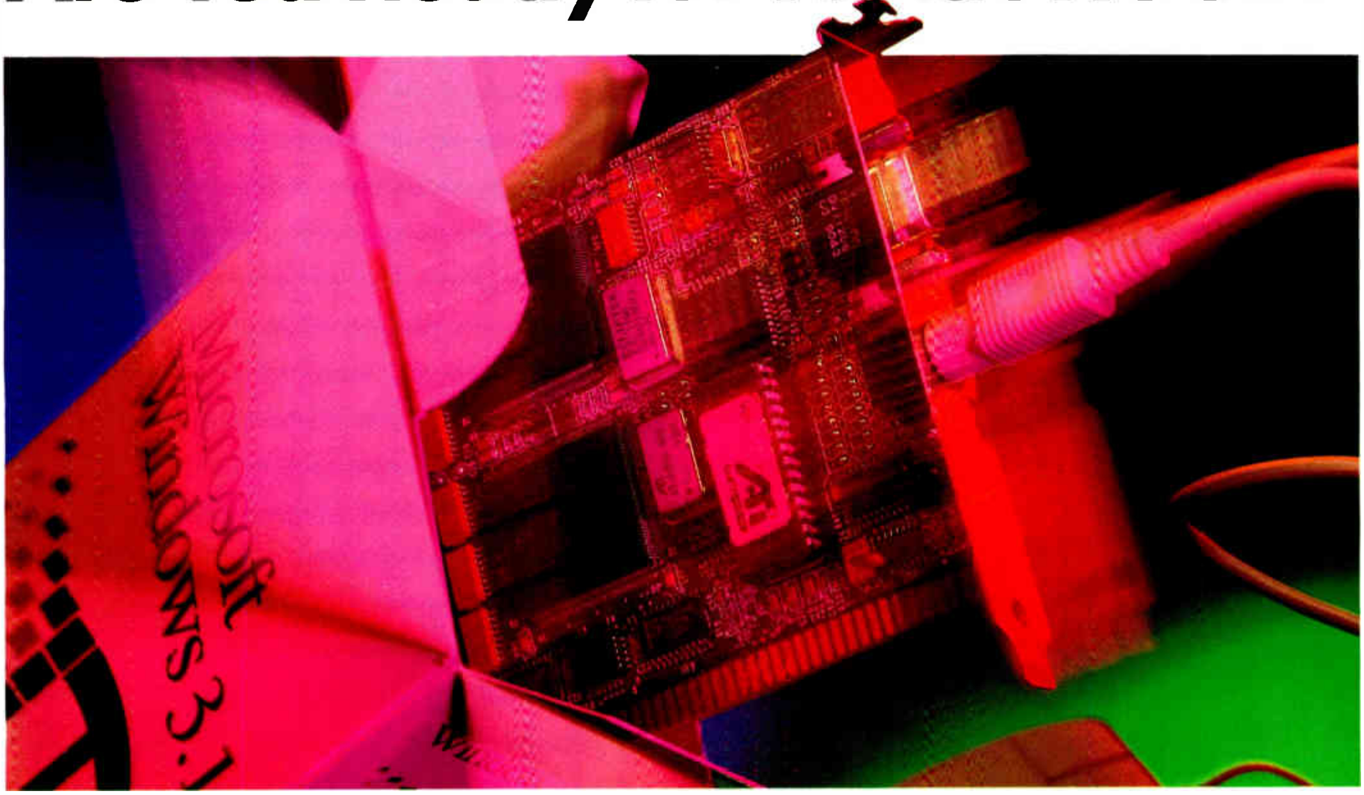
A Refreshing Sight

While certain monitor defects can offend your sense of aesthetics, others can cause more serious problems, such as eyestrain and headaches. The most serious problem is *screen flicker*. At its worst, flicker causes images to pulsate, but your eyes are sensitive to even small levels of screen flicker.

Two major factors determine the severity of flicker. One factor is the vertical scan frequency, or *refresh rate*, of the screen. The refresh rate tells you how many times the entire screen is painted each second. The slower the rate with which it is refreshed, the more noticeable the flicker. Your eye can easily discern flicker when the screen is updated less than 50 times per second (a refresh rate of 50 Hz).

The screen is refreshed 70 times per second under the VGA standard, except in the highest resolution mode, which is refreshed at 60 Hz. When you move beyond VGA resolutions, refresh rates may vary. Some monitors do not have a high enough refresh rate at these higher resolutions. If you plan to run high-resolution drivers, make sure your monitor can maintain an adequate refresh rate at its higher resolutions. The VESA standard calls for a 72-Hz refresh rate for

Are You Ready for Windows 3.1?



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HIGH-RESOLUTION MONITORS COMPARED

Size, weight, resolution, and price are just four of the features you should consider when purchasing a noninterlaced 1024- by 768-pixel color monitor. (● = yes; ○ = no; N/A = not applicable)

	13-INCH MONITORS				14-INCH MONITORS		
Company	Aamazing Technologies	Sampo Corp. of America	Seiko Instruments	Tatung Co. of America	AOC International	Mitsubishi Electronics America	Relisys
Model	CM8486X	AlphaScan Plus KDM-1466	CM1450 14	CM14UAS	CM-337	Diamond Pro 14 FW405-ATK	RE1422
Price	$699	$695	$799	$649	$649	$839	$745
Specifications							
Maximum resolution	1280 x 1024	1024 x 768	1024 x 768	1024 x 768	1024 x 768	1024 x 768	1024 x 768
Diagonal screen size (inches)	13	13	13	13	14	14	14
Diagonal screen size (mm)	330.2	330.2	330.2	330.2	355.6	355.6	355.6
Dot pitch (mm)	0.28	0.28	0.25	0.28	0.28	0.28	0.28
Bandwidth	80 MHz	80 MHz	50 MHz	65 MHz	65 MHz	70 MHz	65 MHz
Horizontal scan frequency	31–64 kHz	30–60 kHz	31–50 kHz	31.5–48 kHz	30–56 kHz	30–58 kHz	30–50 kHz
Vertical scan frequency	50–90 Hz	50–90 Hz	50–90 Hz	50–90 Hz	56–80 Hz	50–90 Hz	47–90 Hz
Overall dimensions (w x h x d) in inches	14 x 13.3 x 15	16.1 x 16.5 x 17.25	13.8 x 13.1 x 15.7	14.5 x 12.9 x 15.2	14 x 15.25 x 13.75	13.75 x 13.9 x 15.25	14 x 15 x 15
Overall dimensions (w x h x d) in mm	356 x 341 x 380	408 x 418 x 440	351 x 333 x 399	367 x 328 x 385	356 x 387 x 349	349 x 352 x 386	356 x 381 x 381
Weight (lbs.)	30	27	33	25.3	28	26	25
Weight (kg)	14	12.4	15	11	13	12	11
Mean time between failures (hours)	20,000	20,000	15,000	35,000	49,300	30,000	33,000
Parts and labor warranty	1 year	1 year	1 year	1 year	1 year	2 years	1 year; 2 years on picture tube
On-site service	○	○	○	○	○	Optional	○
Compatibility							
Text mode	○	●	○	○	○	○	●
TTL/EGA capability	○	○	○	○	○	○	○
Macintosh compatible	○	●	○	○	●	●	●
Standard VGA connector	●	●	●	●	●	●	●
Special VGA connector	○	○	○	○	●	○	○
RGB connectors	○	○	○	○	○	○	○
Power							
110/120 VAC in one monitor	○	○	○	●	●	○	●
110/120 VAC autodetection	●	○	○	○	●	○	○
Ergonomics							
Base tilt	●	●	●	●	●	●	●
Base swivel	●	●	●	●	●	●	●
Polished screen	○	○	○	○	○	○	○
Flat screen	○	○	●	○	○	○	○
Trinitron tube	○	○	●	○	○	○	○
Synchronization Method							
Multifrequency	●	○	●	●	●	●	○
Multiscanning	○	●	○	○	○	●	●
RGB sync on green signal	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RGB external sync	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emission Safety Standards							
Conforms to TUV	●	●	○	●	●	○	●
Meets MPR II emission standard	○	○	○	○	○	●	○
Controls							
Brightness	●	●	●	●	●	●	●
Contrast	●	●	●	●	●	●	●
Manual degaussing	○	○	●	○	○	●	○
Power-on automatic degaussing	○	●	○	●	●	●	○
Horizontal position	●	●	●	●	●	●	●
Vertical position	●	●	●	●	●	●	●
Horizontal size	○	●	●	●	●	●	●
Vertical size	●	●	●	●	●	●	●

	15-INCH MONITORS				16-INCH MONITORS			
Hitachi/ Nissei Sangyo	Mitsubishi Electronics America	Optiquest	Samsung Information Systems	TVM Professional	Idek/Ilyama North America	NEC Technologies	Seiko Instruments	Tatung Co. of America
SuperScan 15 CM1584MU	Diamond Scan 16 FS6605-ATK	2000-D	SyncMaster 15	MD-15+	MF-5217	5FG JC-1741UMA	CM1760LR 17	CM17MBD
$799	$1499	$795	$849	$795	$1695	$1699	$1599	$1799
1024 x 768	1280 x 1024	1024 x 768	1024 x 768	1024 x 768	1024 x 768	1280 x 1024	1280 x 1024	1280 x 1024
15	15	15	15	15	16.4	15.5	16	16
381	381	381	381	381	415.9	393.7	406.4	406.4
0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.25	0.28
65 MHz	100 MHz	75 MHz	75 MHz	75 MHz	55 MHz	135 MHz	100 MHz	100 MHz
30–58 kHz	30–64 kHz	30–56 kHz	30–59 kHz	28–58 kHz	30–57 kHz	27–79 kHz	31–64 kHz	29–65 kHz
50–100 Hz	50–130 Hz	50–100 Hz	50–90 Hz	45–100 Hz	50–90 Hz	55–90 Hz	50–90 Hz	50–90 Hz
14 x 14.75 x 16.3	16.1 x 15.9 x 17.5	14.5 x 15.25 x 15.25	14.7 x 16 x 15.7	16.2 x 14.5 x 15	16.2 x 16.2 x 16.5	16.4 x 17.8 x 19.8	15.98 x 15.65 x 17.52	16.2 x 15 x 18.9
358 x 378 x 414	409 x 404 x 445	368 x 387 x 387	376 x 407 x 397	410 x 370 x 380	410 x 415 x 420	417 x 452 x 503	406 x 398 x 445	411 x 380 x 480
36	40	28	35	32	40	56	51	44
16.5	18	13	16	15	18	25	23	20
20,000	23,000	30,000	20,000	30,000+	29,300	35,000	15,000	35,000
2 years	2 years	1 year	1 year	2 years	1 year	1 year, labor; 2 years, parts	1 year	1 year
○	Optional	○	○	○	○	Optional	○	○
●	○	○	●	○	●	○	○	○
●	○	○	○	○	○	●	○	○
●	●	●	●	○	●	●	●	○
●	○	●	●	●	●	●	●	●
○	●	○	○	○	●	○	○	●
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●	●	●	○	○	●	●	○	●
●	N/A	N/A	N/A	N/A	●	●	●	●
○	N/A	N/A	N/A	N/A	●	●	●	●
●	○	●	●	●	●	○	○	●
●	●	●	○	●	○	●	●	○
●	●	●	●	●	●	●	●	●
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●	●	●	●	●	○	●	○	●
●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●

HIGH-RESOLUTION MONITORS COMPARED

Size, weight, resolution, and price are just four of the features you should consider when purchasing a noninterlaced 1024- by 768-pixel color monitor. (● = *yes;* ○ = *no;* N/A = *not applicable)*

17-INCH MONITORS

Company	Amdek	CTX International	Nanao	Nanao	Samsung Information Systems	Sony Corp. of America	Toshiba America	ViewSonic
Model	Amdek AM1817	1760-F	F550i	T-560i CPD1604S	SyncMaster 4 P17CM	Multiscan HG	FS Multi Frequency	ViewSonic 7
Price	$1299	$1200	$1749	$2699	$1299	$1699	$1900	$1399
Specifications								
Maximum resolution	1280 x 1024	1280 x 1024	1280 x 1024	1280 x 1024	1024 x 768	1024 x 768	1280 x 1024	1280 x 1024
Diagonal screen size (inches)	17	17	17	17	17	17	17	17
Diagonal screen size (mm)	431.8	431.8	431.8	431.8	431.8	431.8	431.8	431.8
Dot pitch (mm)	0.26	0.28	0.28	0.26	0.31	0.25	0.31	0.28
Bandwidth	125 MHz	80 MHz	80 MHz	120 MHz	50 MHz	60 MHz	100 MHz	110 MHz
Horizontal scan frequency	30–76 kHz	30–65 kHz	30–65 kHz	30–78 kHz	20–50 kHz	28–57 kHz	30–65 kHz	30–64 kHz
Vertical scan frequency	40–120 Hz	50–100 Hz	55–90 Hz	55–90 Hz	50–90 Hz	50–87 Hz	50–90 Hz	50–90 Hz
Overall dimensions (w x h x d) in inches	16.6 x 16.4 x 16.5	17.1 x 16.5 x 16.3	15.8 x 16 x 17.8	16.2 x 16.4 x 18.6	16.5 x 17.25 x 17.5	15.94 x 16.81 x 17.25	16.1 x 16.8 x 18.4	16.3 x 17.1 x 18.9
Overall dimensions (w x h x d) in mm	422 x 427 x 419	434 x 418 x 415	401 x 406 x 452	411 x 417 x 472	418 x 441 x 447	405 x 427 x 438	408 x 426 x 467	414 x 434 x 480
Weight (lbs.)	55	44	42	57.5	49.5	48	57	61
Weight (kg)	25	20	19	26	22	22	26	28
Mean time between failures (hours)	40,000	25,000	30,000	30,000	20,000	53,000+	20,000	45,000
Parts and labor warranty	1 year	1 year, labor; 2 years, parts	1 year	1 year	1 year	1 year; 2 years on picture tube	1 year	1 year
On-site service	○	○	○	○	○	○	○	○
Compatibility								
Text mode	●	●	●	●	●	●	○	●
TTL/EGA capability	●	○	○	○	●	○	○	○
Macintosh compatible	●	●	●	●	●	●	●	●
Standard VGA connector	●	●	●	●	○	●	●	●
Special VGA connector	●	●	●	●	●	○	○	●
RGB connectors	●	○	●	●	○	○	●	●
Power								
110/120 VAC in one monitor	●	●	●	○	○	●	●	●
110/120 VAC autodetection	●	○	●	○	○	●	○	●
Ergonomics								
Base tilt	●	●	●	●	●	●	●	●
Base swivel	●	●	●	●	●	●	●	●
Polished screen	○	○	○	●	○	●	○	●
Flat screen	●	●	●	●	●	●	●	●
Trinitron tube	○	○	○	●	○	●	○	○
Synchronization Methods								
Multifrequency	●	●	●	●	●	●	●	●
Multiscanning	●	○	●	●	○	●	○	●
RGB sync on green signal	●	N/A	●	●	N/A	N/A	●	●
RGB external sync	●	N/A	●	●	N/A	N/A	●	●
Emission Safety Standards								
Conforms to TUV	○	●	○	○	●	○	●	●
Meets MPR II emission standard	○	Optional	●	●	○	●	●	●
Controls								
Brightness	●	●	●	●	●	●	●	●
Contrast	●	●	●	●	●	●	●	●
Manual degaussing	●	●	●	●	●	○	●	●
Power-on automatic degaussing	●	●	●	●	●	●	●	●
Horizontal position	●	●	●	●	●	●	●	●
Vertical position	●	●	●	●	●	●	●	●
Horizontal size	●	●	●	●	●	●	●	●
Vertical size	●	●	●	●	●	●	●	●

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Windows helps change all that. Its intuitive interface and pull-down menus eliminate most of the repetitive keyboarding that makes computer work feel confining.

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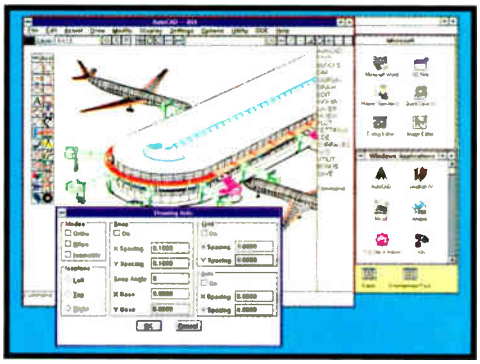
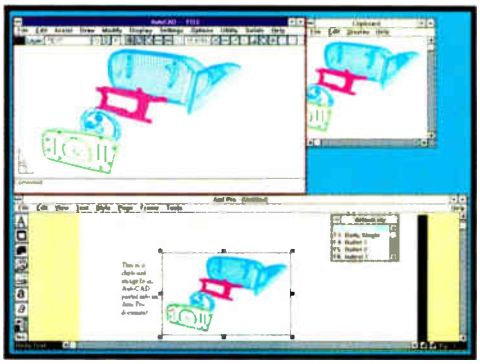


The intuitive Windows interface, tools and icons make AutoCAD far more accessible.



With the Windows clipboard, AutoCAD drawings are easily added to documents and presentations created on desktop publishing, paint, drawing or word-processing software.

Now AutoCAD

Objection #3:

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Okay, let's be honest about this. Maybe you and your pencil can beat the blazing speed of AutoCAD for rough sketching. But AutoCAD leaves your pencil in the dust

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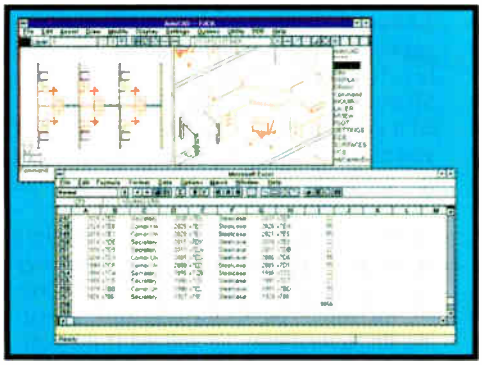
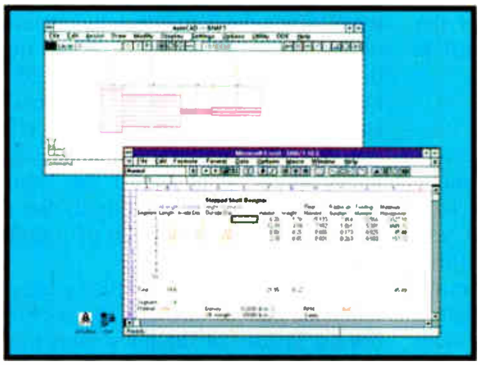
Win.



Using Dynamic Data Exchange, you can eliminate many repetitive tasks by linking AutoCAD to other Windows programs.



AutoCAD gives you the tools to link your drawings to spreadsheets. So you can explore the possibilities of parametric design.

Runs On Windows.

when it comes to designing, making revisions and creating multiple views.

That's not all. AutoCAD on Windows has another way to make you more productive. It's called Dynamic Data Exchange (DDE). With DDE, information flows in both directions between AutoCAD and other Windows applications, like Microsoft® Excel® and Lotus 1-2-3®

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Super VGA and high-resolution VGA.

To avoid flicker, you also should look for a noninterlaced monitor, one that paints each line of the screen as it refreshes the display. The electron beams in interlaced monitors paint every other line of the screen in a single pass. The skipped lines are painted on the next cycle. To create a steady image, the phosphor dots of an interlaced screen must have sufficient *persistence* that they continue to glow until they are refreshed again. While increasing the persistence of the dots reduces flicker, it may cause other undesirable effects such as *ghosting*, the persistence of an old image after a new image appears. Noninterlaced monitors solve the flicker problem without introducing other undesirable effects. All the monitors reviewed here are noninterlaced models.

Problems in *variance* also can turn you into an aspirin junkie. Even if a screen is updated frequently enough to avoid flicker, the updated image may not be in the same place each time. Rapid, jumpy movement of the images is called *jitter*. Slower movement, *swim*, causes the image to waver down the length of the screen. *Drift* causes a more subtle shift of the image over time.

Scan as Scan Can

Another factor to consider is *multiscanning capability*, the ability of some monitors to automatically synchronize to a wide range of video frequencies. If you plan to upgrade your display adapter later on, investing in a multiscanning monitor—rather than in a monitor that is "tuned" to a particular frequency—may make sense.

To run VGA, all monitors must synchronize to a horizontal scanning frequency of 31.5 kHz, the VGA standard. *Horizontal scan frequency* denotes the number of times the electron beams paint a single scan line each second. As long as you stick to standard VGA resolutions, you don't have to worry much about multiscanning capability. As you move into higher resolutions and faster refresh rates, however, you cannot depend on standard frequencies. Some monitors synchronize to the four or five specific frequencies that correspond to the resolutions the monitor supports. This is acceptable as long as your display card generates the frequencies expected by your monitor.

Because they can synchronize to a variety of different video frequencies, multiscanning monitors deliver the best insurance for future upgrades. As long as the signal that is generated by your particular display adapter falls within the range supported by multiscanning monitors, all will be well.

The Trinitron Difference

Does Trinitron technology deliver a sharper image? That's hard to say conclusively, although our experiences indicate that a Trinitron tube offers some distinct advantages. Conventional monitors use a *shadow mask*, a mask consisting of a number of tiny holes, to guide the electron beam. In contrast, long unbroken slits make up a Trinitron tube's mask, or *aperture grill*. The slits allow more light to pass through to the screen, which produces brighter colors. Unfortunately, the damper wire that stabilizes the aperture grill shows up as a very thin black line running across the center of the screen. Larger monitors require a pair of damper wires. The thin line won't bother most people. In fact, you probably won't notice it unless your application has a white background.

A Trinitron tube makes it difficult to measure dot pitch consistently. Typically, vendors measure dot pitch as the distance between the holes in the shadow mask, since the holes directly correspond to the phosphor dots. Because the slots of the aperture grill can be measured only horizontally, the dot pitch numbers of a shadow mask and an aperture grill are not directly comparable. The 0.25-mm specification you see for the Trinitron tubes (see the table) is roughly the same as the 0.28-mm dot pitch of a conventional monitor.

A Trinitron screen employs only one electron gun to fire the three electron beams, instead of the three guns used by a conventional display. With a single gun, the misalignment problems that plague a three-gun system do not arise. Better beam alignment eliminates variance defects, resulting in purer colors.

Trinitron tubes have another advantage: cylindrical screens. The flat top of the cylinder makes the Trinitron screen flat vertically, although it is somewhat bowed horizontally. Other flat-screen monitors, such as those pioneered by Zenith, are flat vertically and horizontally. Flat screens reduce the natural distortion caused by a curved surface. But strangely enough, an undistorted image may take some getting used to. Most people viewing a flat screen for the first time have the strange sensation of "falling into" a screen that bows inward, an optical illusion caused by our natural tendency to compensate for the curved viewing surface of an ordinary monitor.

A flat screen greatly reduces glare, a frequent problem in many office environments. Most of today's monitors are treated with an antiglare coating to minimize reflections, but you can further improve screen readability by using an antiglare shield. The good ones reduce static as well as glare.

Weights and Measures

Your working environment is important for other reasons, too. In fact, work space, rather than cost, may be the major factor limiting the size of the monitor you buy. Large monitors measure over a foot and a half deep and weigh well over 50 pounds. A large monitor simply may not fit in the space you have in mind, and if you have a small-footprint PC, a heavy monitor may squash your system box.

You also should consider your coworkers. The magnetic field of a mammoth monitor can affect the image quality of other monitors in your work area. In addition, your office mates may not appreciate having a huge monitor humming by their heads. Lately, computer users have become more aware of emissions produced by monitors (see the text box "Emission Control" on page 210). Although there are more questions than answers when it comes to safe emission levels, Sweden's National Board for Measurement and Testing has promulgated a good minimum standard, MPR II. If you are concerned about emissions, check the table for a monitor complying with these guidelines.

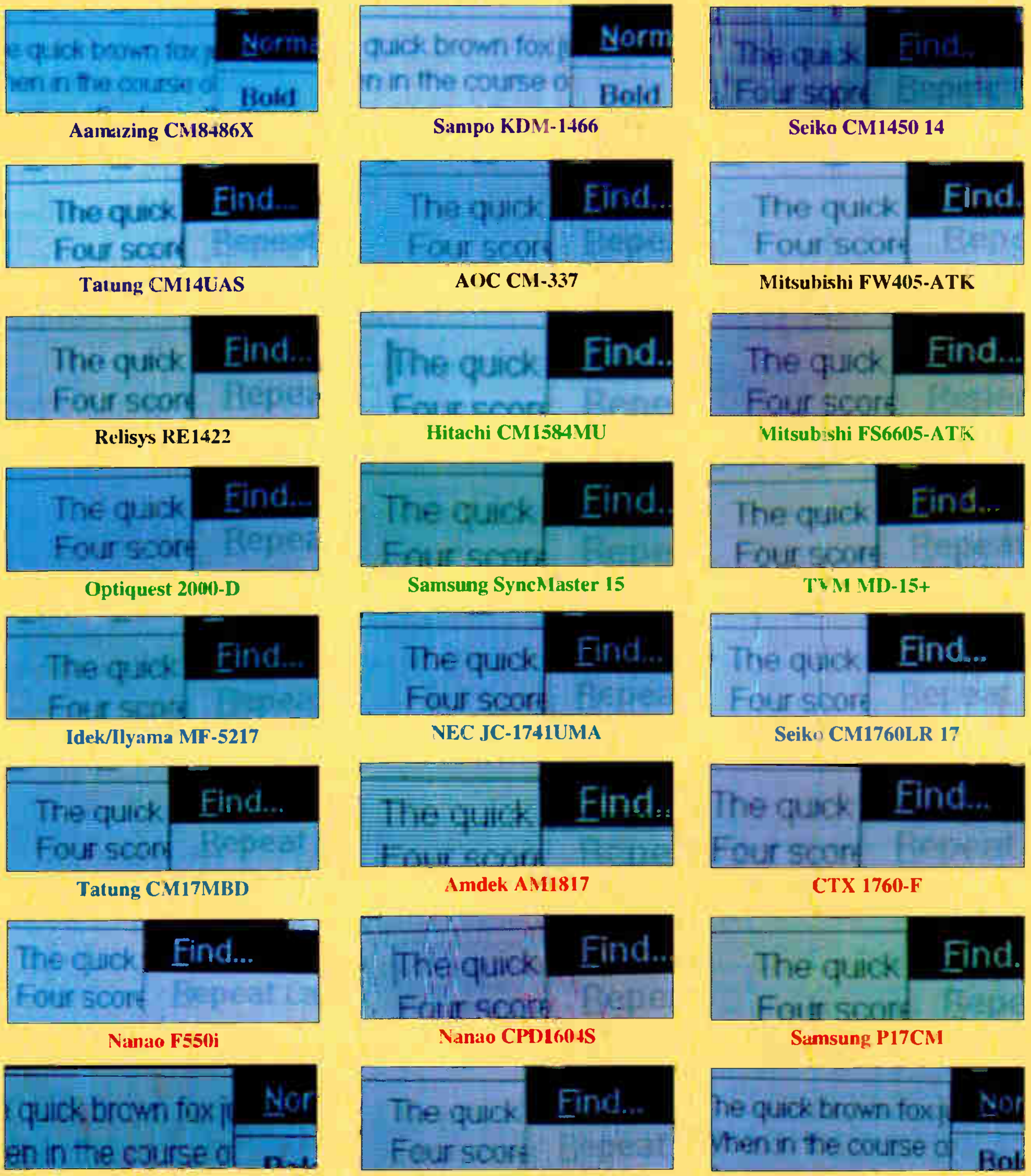
Also be sure to look for a complete range of adjustments to control the size and position of your screen image. Even so, the time you spend carefully adjusting the screen may be wasted if the software you're running tells the monitor to change modes or resolutions. Suddenly, the image on-screen may no longer appear centered, and it may not even fit in the viewing area of the display. Some monitors can "remember" settings for each screen mode, which enables you to adjust the screen once for each mode and resolution; thereafter, whenever the monitor switches to a new mode, it will use the appropriate settings. All the test monitors can properly synchronize images in text mode and at resolutions of 640- by 480- and 1024- by 768-pixels. The ATI VGA Wonder XLdisplay card that we used for testing is VESA compatible.

Stray magnetic fields are another potential source of frustration. They can build up inside your monitor and seriously degrade image quality. *Degaussing* clears the screen of these fields and improves the image. Many monitors automatically degauss the screen when they are first turned on. A manual

Monitor Comparison Chart

A screen-by-screen comparison of the 24 noninterlaced monitors tested by the BYTE Lab. Look for brightness, sharpness of characters, and contrast between the foreground and background.

13-inch *14-inch* *15-inch* *16-inch* *17-inch*



Aamazing CM8486X — Sampo KDM-1466 — Seiko CM1450 14

Tatung CM14UAS — AOC CM-337 — Mitsubishi FW405-ATK

Relisys RE1422 — Hitachi CM1584MU — Mitsubishi FS6605-ATK

Optiquest 2000-D — Samsung SyncMaster 15 — TVM MD-15+

Idek/Ilyama MF-5217 — NEC JC-1741UMA — Seiko CM1760LR 17

Tatung CM17MBD — Amdek AM1817 — CTX 1760-F

Nanao F550i — Nanao CPD1604S — Samsung P17CM

Sony MultiScan HG — Toshiba FS Multi Frequency — ViewSonic 7 degaussing button lets you clear the screen whenever magnetic fields cause a problem.

Of course, placement of user controls is extremely important. In the past, adjustment switches invariably were placed at the rear of the monitor; you had to be a contortionist to use them. Vendors finally are realizing that users need to see their screens while they're adjusting them. Look for controls that are accessibly located on the front or side of the monitor. Also check out the type of control knobs the monitor supplies. Most monitors have large adjustment buttons and dials, but a few come with small, stick-like switches reminiscent of those provided on TVs in the 1970s. Some of the best VGA displays have push-button digital controls that let you adjust the screen image with precision. (See the text box "Screen Colors As You Like Them," below, for details on a control system of a different sort: NEC's innovative system for fine-tuning screen color.)

But your ultimate objective in selecting a color VGA monitor should be to find one that provides crisp, true images without requiring a lot of fiddling with controls. The test results provided in "Monitor Benchmarks," on pages 224, 228, and 230, show how the 24 review monitors stack up.

Front and Center

Tons and tons of numbers make for pretty graphs, but what do they really mean? To present the information gleaned from our 300 tests in a meaningful manner, we distilled the data into nine graphs.

Figure 1 is our version of the classic line-width test; it evaluates the ability of a monitor to produce fine horizontal lines positioned at the center of the display. The smaller a monitor's result in this test, the finer and sharper the image it can produce—and the better the display. Our results put the Aamazing CM8486X, Samsung SyncMaster 15, and Idek/Ilyama MF-5217 at the top of the class; while systems such as Seiko's CM1450 14 and CTX's 1760-F demonstrate lackluster performance. But these values alone do not tell the full story.

In fact, very little can actually be told by looking at raw values such as those in figure 1. Figure 2 presents a more balanced look at line width by graphing the difference between horizontal and vertical line widths and brightness (luminance). Although we haven't charted the monitor results in 640- by 480-pixel resolution, our tests show almost all these monitors display horizontal and vertical lines of the same width and brightness. However, figure 2 shows that switching to 1024- by 768-pixel resolution stresses the equipment to its limit. Horizontal and vertical lines appear to have different widths and brightness. The Tatung CM14UAS, in particular, shows remarkable changes in parameters. The Mitsubishi FS6605-ATK and Sony Multiscan HG show little change in line width, but all of the monitors produced noticeable changes in brightness. On this test, the best monitors are those that exhibit the least amount of overall change: the AOC CM-337, Optiquest 2000-D, and Mitsubishi FS6605-ATK.

Figure 3 graphs monitor bloom by measuring how much the line width changes as the line brightness changes. Again, looking just at raw numbers can produce misleading conclusions. The bloom test sets the monitor at two arbitrary brightnesses. The response to these settings is different on each monitor. Some monitors demonstrate very large changes in brightness; other monitors very little. Rather than blindly chart raw line changes, figure 3 graphs the line width change in relation to the change in brightness. The monitors fall into two clear categories. Monitors such as the AOC CM-337 (which until this test have fared quite well) exhibit very large line width changes in proportion to changes in brightness. Monitors, such as the Hitachi CM1584MU, that fare well on the test exhibit very small changes.

Our next test evaluates swim, jitter, and drift. In simplest terms, this test demonstrates the ability of each monitor to draw a line in the same location time after time. The three components of the graph measure line movement over three time periods. Jitter indicates how far the line moves from its proper position within half a second, swim shows line movement over 10 seconds, and drift indicates line movement over a full minute. Unless you are taking precisely aligned close-up shots of a monitor screen, you probably will never notice drift. It simply happens too slowly. Jitter, on the other hand, is very disturbing to the eye.

The more consistently a monitor can repeatedly draw lines in the same location, the better the monitor. Three standouts in this category are the NEC JC-1741UMA, Nanao CPD1604S, and the CTX 1760-F. Repeatability is more important in smaller monitors than in larger ones because your eye must work harder to see small images.

Screen Colors As You Like Them

NEC's JC-1741UMA monitor provides an interesting feature the company calls the AccuColor Control System. It lets you adjust screen colors directly from the monitor's front control panel. NEC provides a sample color swatch against which screen colors can be matched. The monitor can "remember" two color settings, in addition to its standard factory setting.

Why bother fine-tuning the color of the display? As desktop publishing becomes more prevalent, more people are using computers to produce color "proofs" of their publications.

In fact, with some of the high-end desktop publishing programs, such as the Microsoft Windows version of Ventura Publisher 4.0, you can make color separations right at your PC. In the past, this specialized prepress print process was performed only by specialized service bureaus.

A difficulty arises when the colors displayed on the screen do not exactly match the colors generated by desktop publishers' color printers or their printing service bureaus. Even the selection of different paper coatings alters the color. NEC provides a color-swatch sample that you can print from either your IBM compatible or Macintosh. You then can use the resulting printout to compare the screen against the swatch and make adjustments until the colors match.

Since this feature is little more than the ability to remember the relative intensity settings of a monitor's red, green, and blue electron guns, other manufacturers are likely to follow NEC's lead, if there is sufficient market demand.

Monitor Benchmarks

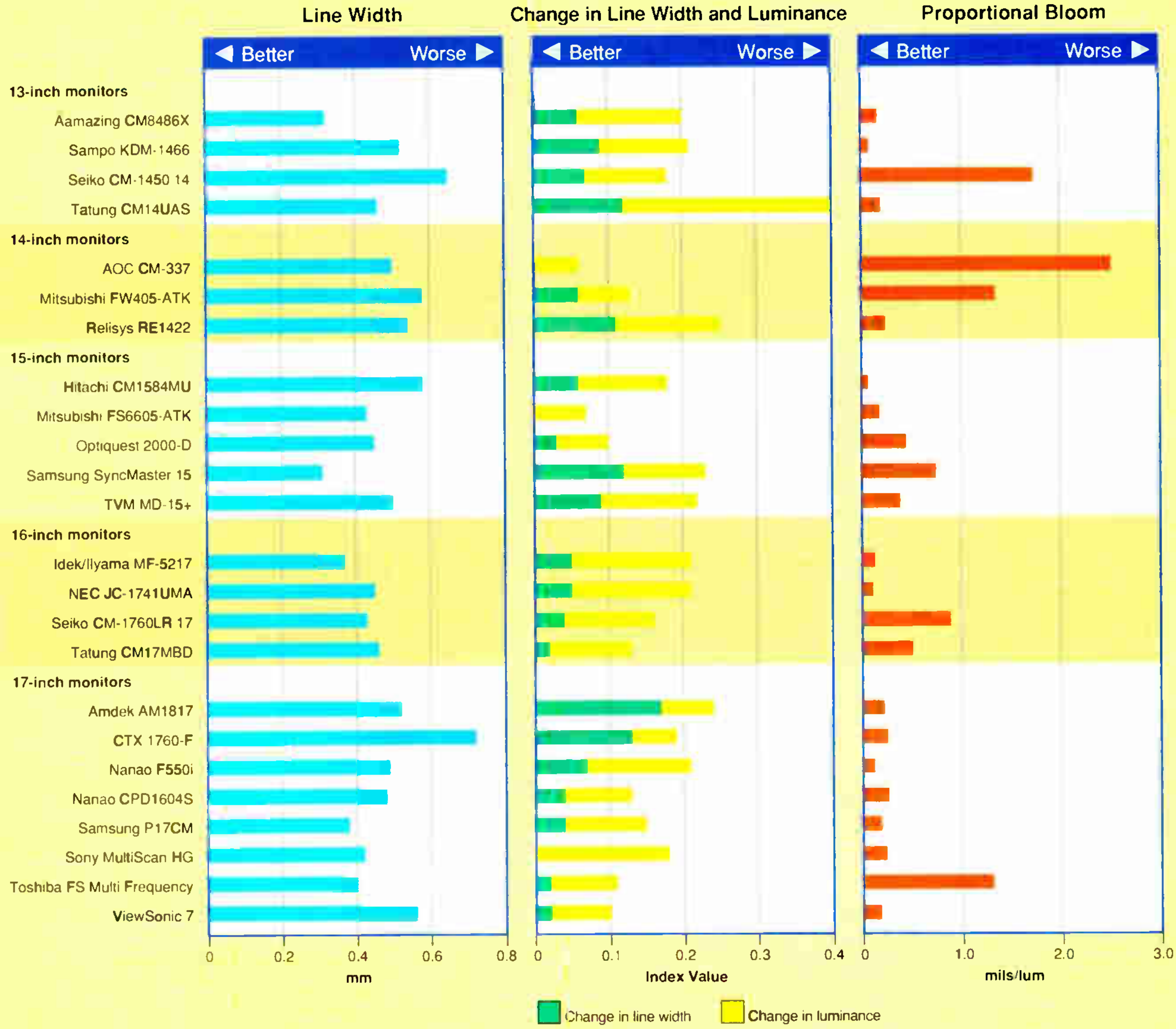
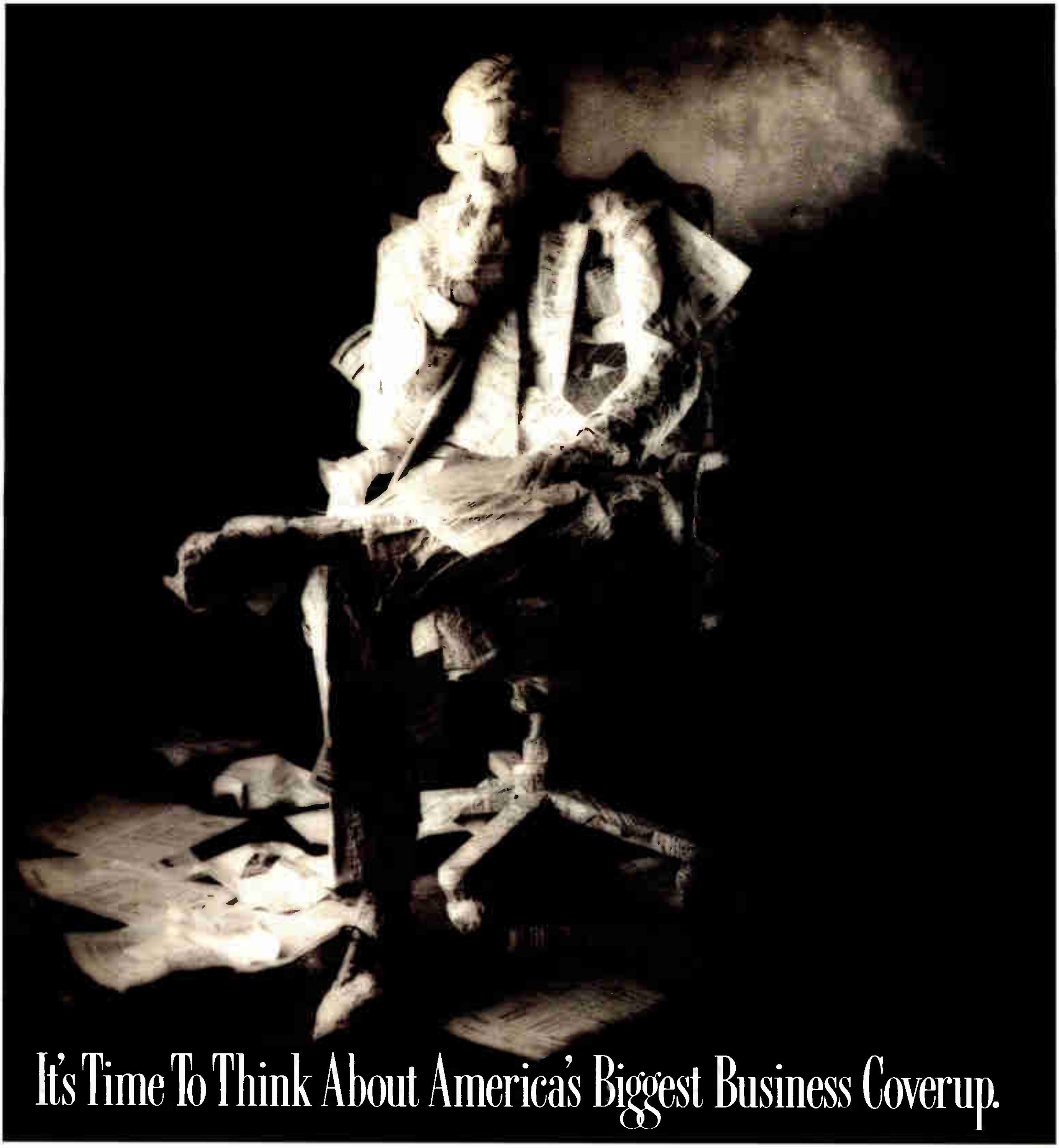


Figure 1. *This test, which compares the horizontal line widths measured at the center of the screen, measures a monitor's ability to create fine, thin lines. Although no clear winners emerge, the Aamazing CM8486X and Samsung SyncMaster 15 come out slightly better than the others.*

Figure 2. *This test compares the luminance (brightness) and line width of horizontal lines against the luminance and line width of vertical lines; measurements are made at the center of the screen. A large value indicates that horizontal and vertical lines on the same screen differ in width and brightness. The AOC CM-337 and Mitsubishi FS6605-ATK draw lines that are consistent in width and brightness. On the Tatung CM14UAS, the brightness of horizontal and vertical lines varies greatly.*

Figure 3. *This test compares how much the line width changes at the center of the screen as the luminance is increased. For this graph, a large value shows a tendency for the line to blur as the intensity is increased. Results on this test separate the 24 monitors into two distinct groups.*



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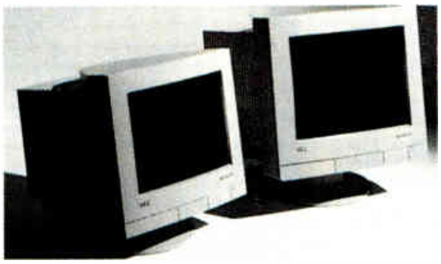

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Monitor Benchmarks

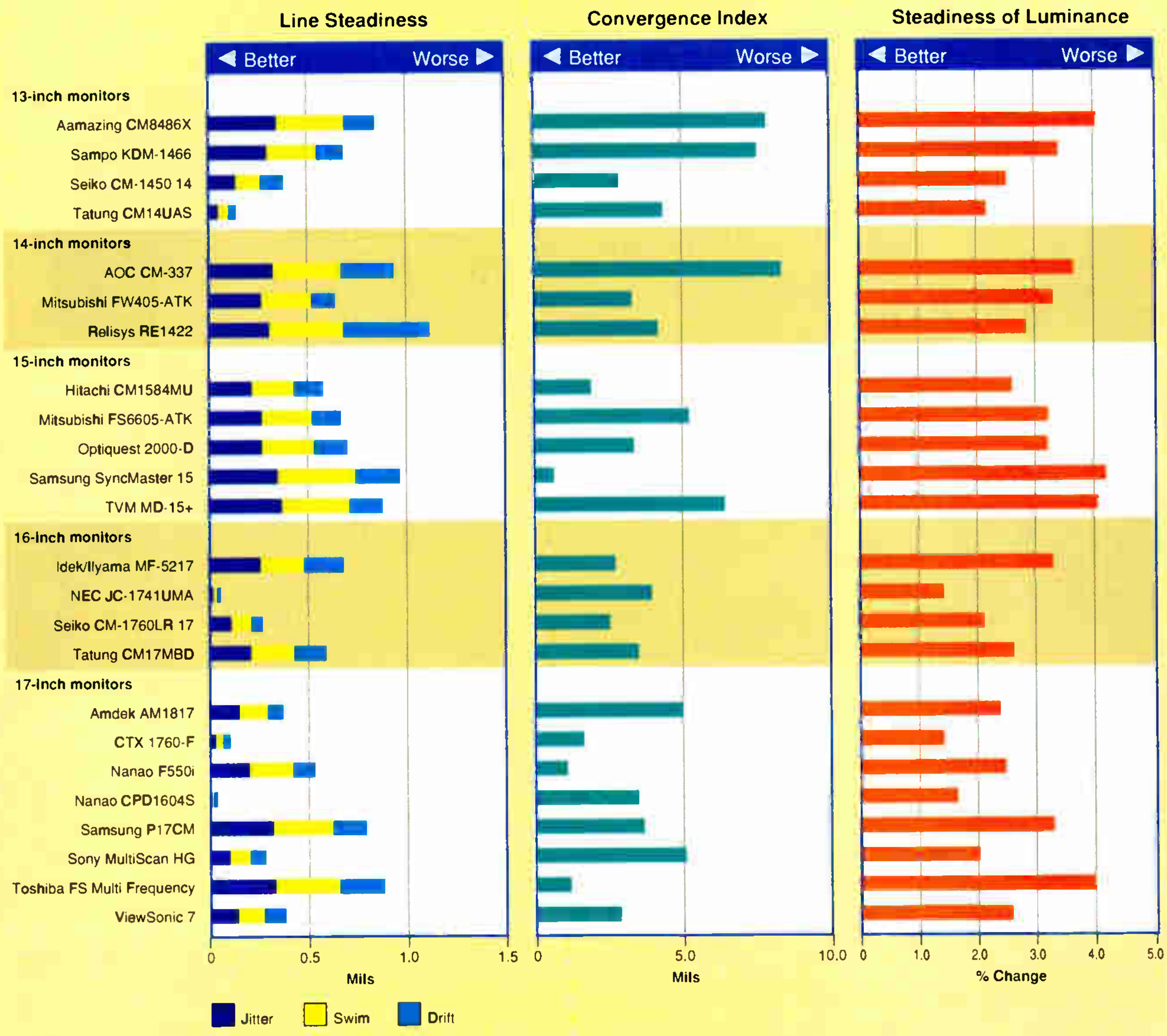

Figure 4. *This test compares the consistency with which lines are placed on the screen; measurements are made at the center of the screen at 0.5-second (jitter), 10-second (swim), and 60-second (drift) intervals. Large values indicate an image that moves about the screen, which causes distortions in the color and brightness of the image. The NEC JC-1741UMA and Nanao T-560i perform very well in this test.*

Figure 5. *This test compares the geometric averages of the three components included in a horizontal line placed at the center of the screen. This value indicates how well aligned the pure red, green, and blue components of a line appear. Monitors with a smaller convergence index have better alignment and therefore provide better color and sharper images. The Nanao F550i and Samsung SyncMaster 15 outperform the field in this category.*

Figure 6. *This test compares the change in luminance measured over a two-minute period at the center of the screen. Luminance contributes to a jittery, or wavy, screen image. The steadier the luminance, the more stable the displayed image. Although all the monitors tested perform well in this test, the NEC JC-1741UMA and CTX 1760-F lead the pack.*

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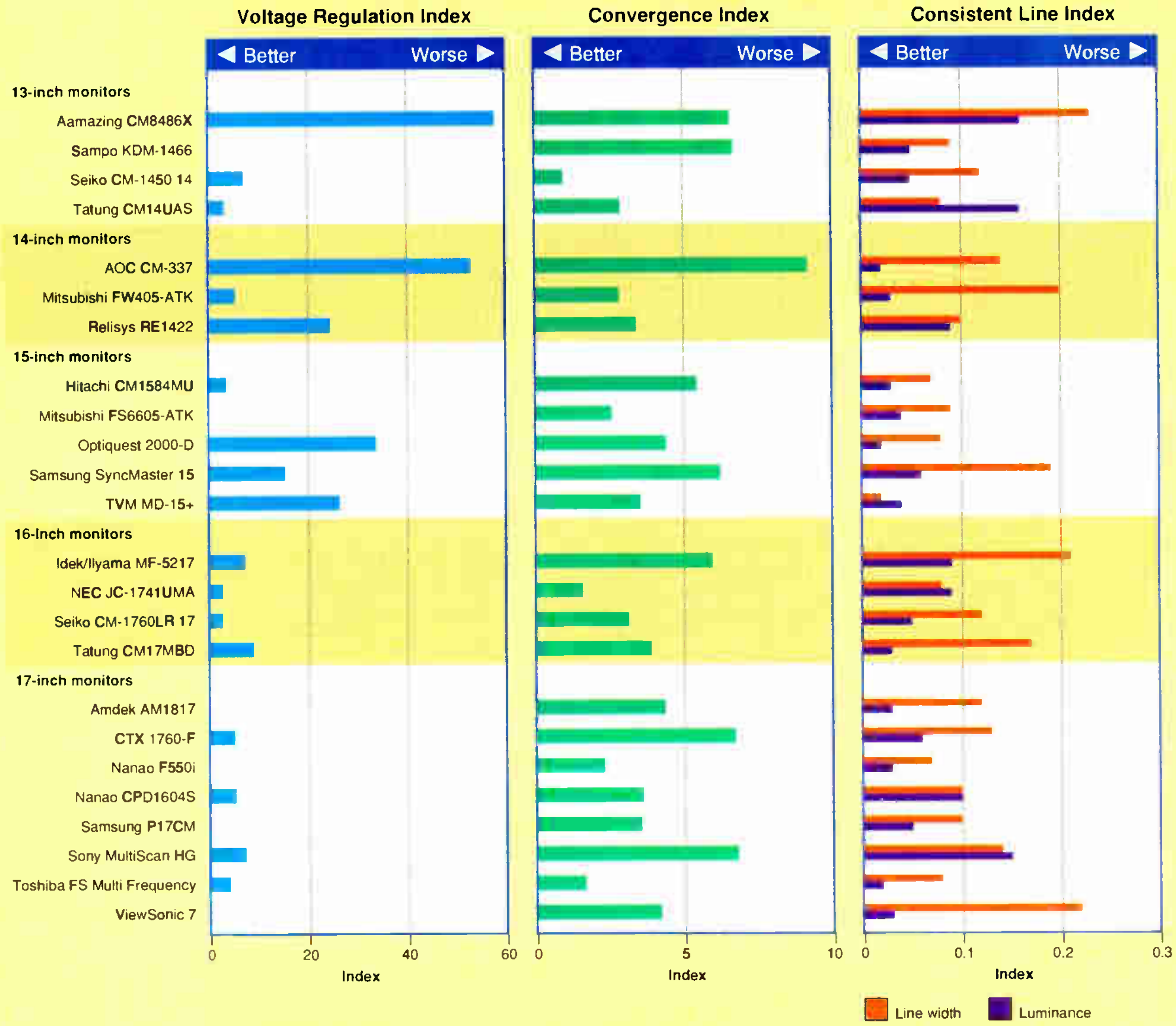

Figure 7. *This test indicates how well a monitor can maintain a consistent image size as the contents of the screen change. A monitor's ability to maintain the size of an image is particularly important for multimedia applications such as full-screen movies. Six of the monitors tested do not show any noticeable change.*

Figure 8. *This test compares how well the component colors of a line converge at the center of the screen against how well they converge when the line is located in the upper-left corner of the screen. A low value on this graph indicates that an image is displayed consistently no matter where on the screen it is placed. The NEC JC-1741UMA and Seiko CM-1450 14 perform admirably.*

Figure 9. *This test compares the differences between line width and line luminosity when measured at the center of the screen and at the upper-left corner of the screen. A low value indicates that the intensity of an image is consistent and it does not blur as you move it from the center of the screen to the corner.*

The test for convergence measures the ability of a monitor to align red, green, and blue lines on the screen. Alignment affects a monitor's ability to display sharp, brilliant colors. Figure 5 provides a convergence index that is the geometric average of the horizontal and vertical red, green, blue convergence readings. Unless a monitor's convergence capability is extremely good—as it is for the Samsung SyncMaster 15—or poor—as it is for the AOC CM-337—you can't judge convergence solely by the eye. All color monitors exhibit convergence problems, but the human eye is so skilled at detecting these differences that even reasonably good monitors, such as the Tatung CM17MBD, appear to have terrible convergence problems if you view only the red, green, and blue lines on the screen.

Consistently drawing a line of the same brightness is as important as consistent color alignment. Figure 6 shows the percentage change in brightness of a line viewed over a two-minute period. Although some of the monitors exhibit half the change of others, this category lacks an outstanding winner. All the review units exhibit an excellent ability to regulate the line brightness. This test procedure did, however, quickly weed out several interlaced monitors that were inadvertently sent to us for review. All the interlaced monitors we ran through this test show luminance changes of nearly 20 percent, which explains why high-resolution interlaced monitors quickly leave your eyes feeling strained.

On the Fringes

When you look at a display, you look beyond the center of your screen. What happens around the edge of that screen is as important as what's going on in the center. Figure 7 evaluates a monitor's ability to provide an image that is stable in size. The number of screen dots that are active, and the intensity of those active dots, can cause the image to change size. The more active the bright dots, the larger the image. This phenomenon is typically a result of poor voltage regulation within the monitor. It is particularly annoying when viewing rapidly changing screen images.

This test is performed by displaying a single vertical line at the far right of the screen and marking its position. Most of the monitor screen is then painted white. The test measures how far the line on the right of the screen moves. This process is repeated for the top of the screen, using a horizontal line. The value graphed in figure 7 is the average of these two readings.

Six monitors, the Sampo KDM-1466, the Mitsubishi FS6605-ATK, the ViewSonic 7, the Samsung PC17CM, the Nanao F550i, and the Amdek AM1817 don't perform merely well, they perform excellently. On none of these six monitors could our equipment detect any change in size. Images on the Aamazing and AOC monitors, on the other hand, bounce around grotesquely. With monitors that have poor voltage regulation, you can expect to see rapid changes in size whenever a large proportion of the screen changes color or intensity.

The remaining two graphs document how well the monitors do when images are moved from the center of the screen to the upper-left corner. The test results provide an indicator of the screen's overall image quality.

Figure 8 provides a relative index of the difference between convergence quality at the center of the screen and convergence quality in the upper-left

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corner. As before, monitors exhibiting the smallest differences provide the most consistent display quality. Be especially wary of displays whose results in figures 5 and 8 give them a consistently poor rating across the entire screen.

Our testing puts the Seiko CM-1450 14, NEC JC-1741UMA, and Toshiba FS Multi Frequency in the lead on this benchmark, indicating that the color images located in the center of these displays won't be distorted when moved to other screen areas.

Figure 9 shows the variance in line width and luminance between the center and upper-left corner of the monitor. With several noticeable exceptions, the monitors performed well in this test.

The Eyes Have It

The table and figures in this article provide the BYTE Lab test data you'll need to start your monitor evaluation process. With this information, you can quickly dismiss poor performers and concentrate on weighing the price and performance of the other models.

In the end, though, your personal preferences probably will count for a lot. Unlike most PC components, monitors should be a "try before you buy" proposition. Take your test software, or a few sample images, to the store and try it on different monitors. If possible, compare your top choices side by side. That's how we made our top selections.

In the world of 16- and 17-inch monitors, the $1139 ViewSonic 7 gets our vote as the best overall monitor: It provides reasonable quality at an excellent price. However, if we had to choose a single monitor to put on our desks, it would be the Nanao F550i. This $1749 monitor competes favorably with the newer flat-screen $2699 Nanao CPD-1604S and wins hands-down when you factor in price.

For smaller monitors, the 15-inch Optiquest 2000-D, priced at $795, is the overall performance leader, followed closely by the 14-inch AOC CM-337 ($649). Although earlier we warned you against using monitors smaller than 16 inches, the price gap between a 16- and a 15-inch monitor is sufficiently large to compel us to recommend a 15-inch monitor over the pricier 16-inch displays. ■

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LIST: $1195 **PS** Price: $1049

FastFaxts 334-052

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High C 386/486	795	749
QEMM 386	100	75
SVS C3/ANSI C Comp.	1195	325
WATCOM C9.0 386	895	739
C Code Builder	695	579

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OPTASM	150	145

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dB/LIB Professional	189	179
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MS QuickBASIC V4.5	99	69
QuickPak Prof. V4.0	199	189

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Watcom C 9.0	495	439

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Instant Replay Prof.	795	769
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Show Partner F/X	395	295

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Essential COMM	329	249
Greenleaf Comm Library	359	329
Procomm Plus	119	99
QuickComm	149	129
Comm-DRV	90	79
Comm-LOG	90	79

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CLARION Prof. Dev.V2.1	845	475
Clipper 5.01	795	570
dBASE IV	795	549
dBMAN V	295	219
dBXL	249	169
FilePro Plus	699	669
FoxPro 2.0	795	499
Paradox V3.5	795	555
QuickSilver	599	399
R:BASE 3.1	795	645

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Genifer	395	289
Pro-C 2.5	795	739
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DBMS TOOLS & LIBRARIES

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B-Tree Dictionary	149	139
CLEAR + for dBASE	200	179
CodeBase 4.5	395	349

The PKWARE Data Compression Library
by PKWARE

The PKWARE Data Compression Library allows software developers to add data compression technology to applications. The application program controls all data I/O, allowing data to be compressed or extracted to any device or area of memory. Only 35K of memory is needed to compress data, and only 12K is needed to extract data. Compatible with MSC, BC++, TC, TP 6.0, Clipper, Basic 4.5,7.1, ASM.

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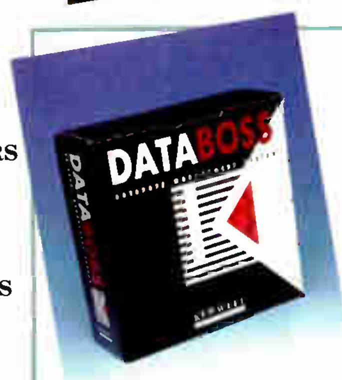

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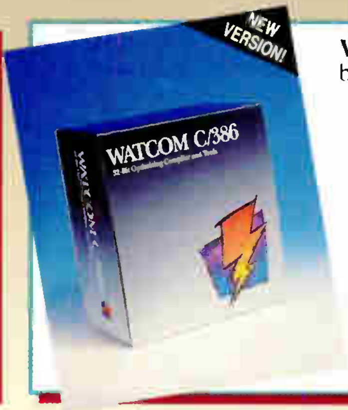
LIST: $995 **PS** Price: $895
FastFaxts 2001-006



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dSalvage Professional	200	195
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Faircom c-tree Plus	595	495
Flipper	295	279
FUNCky.LIB	249	239
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Net Lib	299	269
Novell BTrieve	595	479
Pro Clip	99	95
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R&R Code Generator	199	159
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graphics-Menu	249	229
GSS Graphics Dev't Tlkt.	795	699
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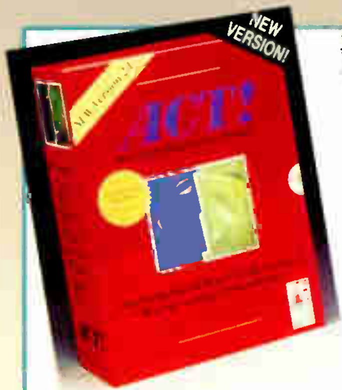
LIST: $295 **PS** Price: $265

FastFaxts 2835-004



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Norton Utilities 6.0	179	149
pcANYWHERE IV	179	159
PC Tools Deluxe 7.1	179	149
PC-KWIK Power Pak	130	95
QuickNet	199	195
Remote2	195	139
Speak2Me	99	98
SpinRite II	89	79
Turbo EMS	100	89

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	LIST	PS
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Microsoft Pascal	300	199
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Pascal ASYNCH Mgr.	175	159
Turbo Pascal 6.0	150	109

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dBFAST/Windows	550	399
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Graphics Server SDK	495	455
KnowledgePro Windows	549	395
MS Windows V3.0	149	119
MS Windows SDK V3.0	500	365
Multiscope Windows Deb.	379	315
Objectrieve/Windows	395	379
ObjectVision by Borland	150	129
POET/Windows	499	329
Quadbase-SQL for Win.	995	949
Quick C for Windows	199	149
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Visual BASIC	199	165
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	LIST	PS
Mach^{TEN} Workstation	$595	$475
Development System Option	$395	$325

FastFaxts 4622-001 (Work station)
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LIST: $495 **PS** Price: $469

FastFaxts 5305-001

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HARDWARE

Downsizing Media: 3½-inch MO Drives Arrive

DAVID A. HARVEY

Data. You've got more of it than you know what to do with. And weighing the benefits of fixed storage against removable storage is a complex balancing act. While fixed storage brings large capacity and quick access, removable storage provides data security, "sneakernet" data transfers, backup, and a way to install new programs.

What we need is a standardized, affordable, high-capacity, random-access removable desktop storage device. Enter the 3½-inch magneto-optical disk drive. Packing 128 MB of rewritable data onto a 3½-inch form-factor MO disk for about $2000, these drives promise a desktop solution that may end our storage woes. And with an average seek time of 40 milliseconds and a data transfer rate of 625 KBps for the typical device, the MO drive is not much slower than existing low-end hard drives.

In addition to the capacity and removability benefits, some vendors are touting the promise of portable environments. Essentially, the new drives could let you create spreadsheets, reports, or presentations in whatever operating system and application suite you desire. You could save that same environment on a 3½-inch MO disk and boot your own configuration anywhere you travel.

For this roundup, I looked at four 3½-inch MO drives: Acumen's AcuOptic-128E, IBM's PS/2 3.5-inch Rewritable Optical Drive, MicroNet Technology's MO-128/DOS, and Pinnacle Micro's REO-130S (see the table). I chose these drives because they were available in production versions in time for testing and because they provide a representative sample of original-drive manufacturers. I also looked at an early version of Sony's RMO-S350 drive, which at press time was slated to ship in the second quarter in commercial quantities to retail outlets under the Sony brand name (see the text box "Sony's Retail Entry Shows Promise" on page 244).

BYTE ACTION SUMMARY

- **WHAT MO DRIVES DO**
  These 3½-inch magneto-optical drives deliver 128 MB of removable storage in a small form factor with an average access time of 40 ms and data transfer rates of about 625 KBps.
- **LIKES**
  Size and convenience for a reasonable price, relatively fast access times, and support for optical ROM.
- **DISLIKES**
  Lack of standardization among software drivers.
- **RECOMMENDATIONS**
  For fit and finish, Pinnacle Micro's REO-130S emerges as the best overall choice.

3½-inch Considerations

Three potential problems come to mind when considering the viability of 3½-inch MO drives: cost, performance, and compatibility. At about $2000, a 3½-inch MO drive costs roughly as much as three 200-MB SCSI drives. However, cost becomes less of a factor when you add in multiple disks at $60 each. For example, a $600 200-MB SCSI drive costs $3 per megabyte of storage. A base 3½-inch MO drive with one piece of media costs about $15 per megabyte. But by the time you acquire six pieces of media, the cost plummets to about $3 per megabyte. The more you use it, the less it costs.

Performance, too, begins to diminish in importance when you consider how the drive is likely to be used. Much faster

PHOTOGRAPHY SCOTT PARKER / AVIS STUDIO © 1992

than a floppy drive and far more convenient than a tape, a 3½-inch MO drive is useful for storing archival copies of files and for primary storage of large files that need to be loaded only once; it could even serve as a primary storage system. However, while performance considerations may dictate that you store your current work on your hard disk, you could keep libraries of images, drawings, and other elements on the MO disk.

Another issue is software driver compatibility. Without it you can't interchange media between different vendors' drives. Due to a lack of industry standards in this area, there just isn't compatibility. While the hardware itself is compatible, software drivers create the problem (see the text box "A Confusion of Drivers" on page 246).

The future of the 3½-inch MO drive looks mixed. If driver incompatibilities remain and prices stay in the $2000 range, the drives seem destined to remain niche products. However, if prices fall and driver incompatibilities disappear, MO drives could be poised to take over the desktop.

MO Is Better

At the data-encoding level, 3½-inch rewritable optical drives are indistinguishable from their 5¼-inch siblings. To record data, a laser heats the magnetic-alloy recording layer to its Curie temperature (about 150°C). At this temperature, the coercivity of the recording layer tends toward 0, and the medium becomes susceptible to magnetization.

MO writes are not simply a matter of magnetizing a bit. Encoding data requires two passes. The first pass restores the magnetic orientation of the medium to its "virgin" state; the second pass actually encodes the data by selectively magnetizing bit-size areas.

A detector picks up the light reflected from the magnetized (rotated) areas of the disk and, in turn, sends an electrical signal to a comparator. Based on the detector's input, the comparator then decides whether a given area contains a 0 or a 1. Unlike 5¼-inch disks, 3½-inch MO disks are single-sided and can hold 128 MB of data.

When you get into the electronics and mechanics of 3½-inch MO drives, the differences introduced by the change in form factor begin to appear. Basically, 3½-inch MO drives use miniaturized components, use more LSI logic, and spin at faster speeds, which adds up to greater performance.

Some drives support the optical-ROM specification. O-ROM is essentially a miniaturized version of CD-ROM in which information is burned permanently onto the polycarbonate substrate in a series of pits and islands that represent 0s and 1s.

Spinning Platters

I installed each 3½-inch MO drive according to its manufacturer's recommended default configuration on a Gateway 386/33 outfitted with an Artisoft AE-3 Ethernet adapter, an S3-based Actix Systems Quantum graphics card jumpered for 8-bit operation, 8 MB of RAM, and a Maxtor LS2000A IDE drive. The systems software consisted of QEMM 6.02, the LANtastic Network Operating System 4.0 drivers, and the software drivers for the disk drive. I chose this configuration to simulate a real-world environment.

I conducted five tests on each MO drive. To simulate moves of large files, I created a 25-MB data file and used the XCOPY command to move it to and from the MO drive (see the figure). Throughput tests consisted of the BYTE Lab's optical suite, which creates a 25-MB directory structure on the hard drive and copies it to and from the optical drive using XCOPY. Both copy tests formatted the MO drive prior to the XCOPY. In checking the seek times, I used the BYTE Lab's Time-Find test to search the MO disk for a nonexistent file.

Compatibility tests consisted of checking for O-ROM performance and media interchangeability. For O-ROM performance, I used Sony's O-ROM demonstration disk, produced by Autodesk, which contains a cornucopia of images, CAD drawings, and Animator animations. For media interchangeability, I formatted a disk in each drive, copied some data files onto it, and checked to see if other drives could read it.

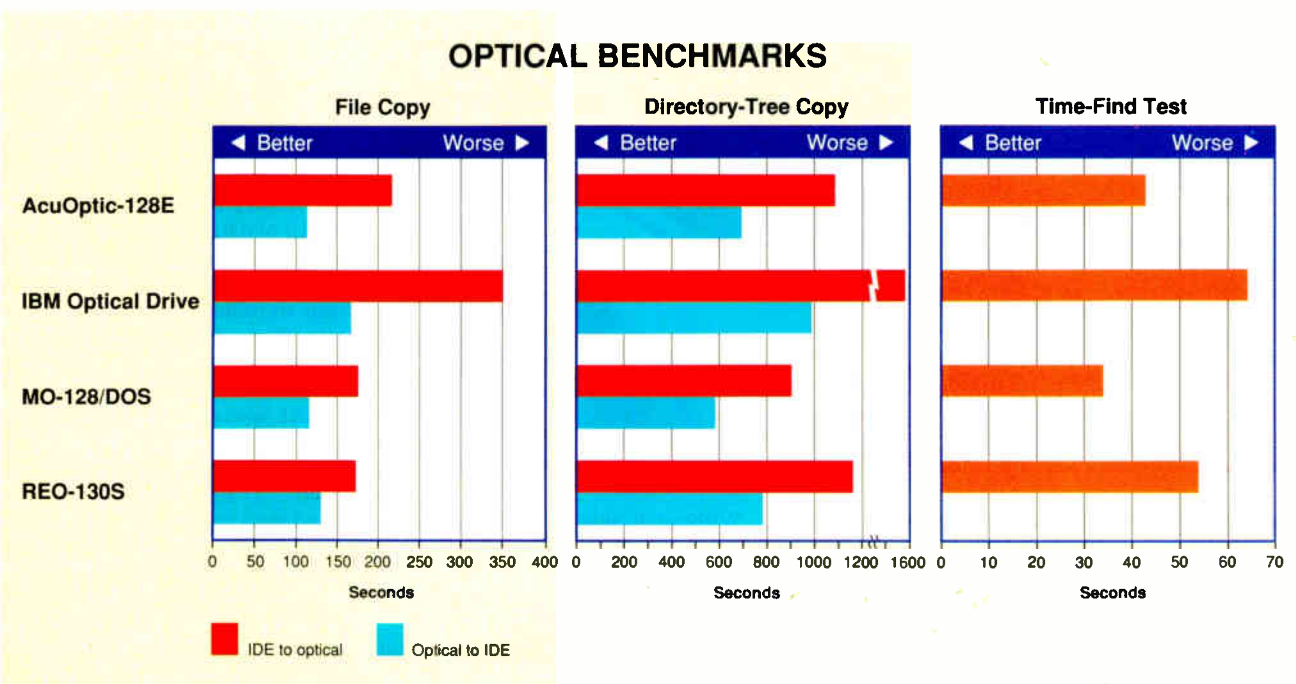
I was overjoyed to see that all the MO drives came with external terminators. This is more than smart. SCSI bus reconfiguration doesn't require taking off the back plate of the drive and pulling the terminating resistors; it becomes plug and play—almost. Most of the drives came with fully featured host adapters, complete with on-board BIOSes, floppy drive controller logic, and connectors.

Depending on your system configuration, you may not need as extensive a controller as the ones that come with these drives. In some cases, configuring the adapters for use with secondary drives created installation headaches. If

3½-INCH MO DRIVES COMPARED

While most 3½-inch MO drives are mechanism-compatible, the controller and software you use determines whether media written on one can be read on another. In general, they can't. (● = yes; ○ = no; N/A = not available.)

Product	AcuOptic-128E	IBM Optical Drive	MO-128/DOS	REO-130S
Price	$2995	$2155	$2240	$2195
Drive manufacturer	MOST	N/A	Sony (CM-301)	Sony (CM-301)
Mechanism compatibility	●	●	●	●
Average seek time (ms)	35.2	83.2	40	40
Rotational speed (rpm)	2400	1800	3000	3000
Transfer rate sustained (KBps)	512	N/A	625	625
Controller	16-bit Future Domain 1680 controller	8-bit Corel Systems LS2000 SCSI adapter	16-bit NCR-based SCSI adapter	16-bit Western Digital 7000-Fasst controller
Software	Future Domain Disk Maestro	Corel Systems CorelDriver 2.20	Adaptec's ASPI driver and AFDISK utilities	Columbia Software SST
Software compatibility	○	○	● (RMOS)	○
O-ROM capability	○	●	○	○



Benchmarks consisted of five components. The File Copy benchmarks measured the time needed to copy a 25-MB file from an IDE drive in the host computer to the optical drive and the time to copy the same file from the optical to the IDE drive. The Directory-Tree tests measured the time to copy tree structures in the same two ways. The Time-Find test measures the time taken to search for a nonexistent file. All results are in seconds.

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Circle 115 on Inquiry Card (RESELLERS: 116).

V E R B A T I M®

Sony's Retail Entry Shows Promise

At press time, Sony planned to sell the RMO-S350 drive under its own name to retail customers, which would make it one of the first commercial magneto-optical (MO) products from Sony. I was able to evaluate an early version of the drive and beta versions of associated software and found this to be a solid package.

The drive came in a sturdy metal case with a removable fan filter, a ground terminal, dual SCSI ports, and a bank of DIP switches to set drive address, termination, parity, termination power, automatic spin-up, and manual-eject enable. The plastic front panel had the usual power LED, drive LED, manual-eject, and automatic-eject mechanisms.

The controller card included in my early version was a 16-bit Adaptec 1520 with internal and external SCSI connectors and jumpers for interrupt-request, DMA, and BIOS address manipulation.

The beta version of Sony's RMOS utility software appeared to be designed

able optical media. While it does not have the universal functionality of Columbia Software's SST or CorelDriver, it offers a host of removable-media-specific options and was the best suited to deal with 3½-inch MO drives.

One useful feature is that the RMOS Macintosh drivers support Apple File Exchange. As a result, you can create and use DOS partitions on Macs, allowing you to exchange files, up to 12 MB

The menued RMOS utility delivers most basic media-manipulation tools, including partitioning, low-level and high-level formatting, defect management, and a utility that lets you analyze a disk's format mode. RMOS promises to be very easy to use, in part because it does not require that you reboot after making changes and it makes it easier to choose among floppy disk and partitioned format modes. Note that to high-level-format the RMO-S350 in floppy disk format, all RMOS does is call the standard DOS FORMAT utility.

The RMO-S350 also performed well in the benchmark tests, hanging with the pack in partitioned mode and lagging only slightly behind on the large-file move in floppy disk mode.

At press time, the suggested retail price of the Sony-branded RMO-S350 was $2295. General retail distribution is slated for early June. Overall, this package shows a lot of promise for its multitude of formatting options, as well

---

ou're among the memory-conscious, you may not relish the thought of trying to fit more adapter BIOSes into your system's already shrinking upper memory block and may want to use a controller that lets you disable the BIOS.

The manufacturers' recommendations for dealing with the media varied widely. Some insisted that you use their software to perform a low-level media FORMAT, a process that can take up to an hour. Others just let you use their supplied partitioning scheme and then make use of the DOS FORMAT command.

Similarly, the utilities that came with the MO drives spanned the spectrum of functionality from full-featured packages with SCSI diagnostics, like CorelDriver and Columbia Software's SST suites, to more media-oriented packages, like Future Domain's Disk Maestro.

All the 3½-inch MO drives performed fairly equally in the benchmark tests, except for the IBM drive, which came in dead last because of its slower rotational speed. Differences between the Sony CM-301-based units result from different implementations of the SCSI adapter and different driver software.

ACUMEN ACUOPTIC-128E

Acumen's $2995 AcuOptic-128E was the highest-priced and most incomplete package I received. The package included a 16-bit Future Domain 1680 controller, with internal, external, and floppy drive connectors; Future Domain's Disk Maestro software; and a floppy disk labeled "Acumen" (which I later discovered was used in the Maestro installation). The package also contained a SCSI cable and a terminator.

The fan-cooled AcuOptic-128E drive has a grooved plastic cover, a push-button SCSI address selector, a power button, and SCSI connectors on the back panel. The front panel contains the manual-eject and automatic-eject mechanisms.

The documentation comes up short. It spends a lot of time discussing the functionality of MO drives in general but has little product-specific information. The Future Domain manual is also weak. The Acumen manual covers the basics of installing either the external or internal models of the AcuOptic-128E but contains virtually no troubleshooting information and makes no mention of the steps required to get the drive and bundled software to work together.

The Future Domain installation software is fairly well written and easy to use, taking you step by step through the process of formatting, partitioning, and DOS-formatting a cartridge. In addition, I found that once the AcuOptic-128E drive was low-level formatted and partitioned with the Future Domain utility, it would accept and function with a standard DOS FORMAT. But the Future Domain controller software is not compatible with the other software drivers.

I had an initial problem installing the AcuOptic-128E on the Gateway test system, which I've used for several years

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A Confusion of Drivers

If you format media in a Sony CM-301 3½-inch magneto-optical drive, you should be able to read it in another CM-301, shouldn't you? In fact, at the disk drive level, both Sony and Mass Optical Storage Technologies drives are compatible. The problem lies in the type of software used. Installed as a device driver and used as utilities from the command line, the software controls the partitioning and formatting of the disks. Unfortunately, each driver package has its own way of doing this, and the result can be mutually incompatible disks.

For example, I took my test disk from the Pinnacle Micro REO-130S drive, attempted to read it on MicroNet Technology's MO-128/DOS drive, and failed—despite the fact that both vendors use a Sony CM-301-based drive. When I hooked the MO-128/DOS up to the Pinnacle Micro-supplied Western Digital controller, however, I could read the original REO-130S formatted disk.

The media formatted in the MO-128/DOS was readable on the early version of the Sony RMO-S350, and media formatted in partitioned mode on the Sony drive was readable on the MicroNet drive. The reason, unfortunately, is not that the drives are compatible. MicroNet and Sony both use Adaptec equipment, and Adaptec and Sony cooperated on the construction of Sony's beta RMOS software.

This points to an important lesson for anyone who needs to manage installations of multiple disk drives: Use the same controller and software on each workstation, and you'll be able to share data. Better yet, go with controllers that are compatible with the advanced SCSI protocol interface, and use a universal driver package.

with an enormous number of drives and cards. When the BIOS on the SCSI card was enabled, the machine refused to boot from its hard drive.

With the help of Acumen's technical support, I traced the problem to an older BIOS in the Gateway. It was only by booting from a floppy disk that I was able to get the system running. Subsequent testing on a newer Gateway in the BYTE Lab revealed no coexistence problems between the Future Domain BIOS and the IDE hard drive and controller.

The AcuOptic-128E is manufactured by Mass Optical Storage Technologies (MOST). Drives shipped since December 1991 feature mechanism-level compatibility with the Sony CM-301–based drives, an average seek time of 35.2 ms, and a 512-KBps sustained transfer rate.

The current Acumen drive does not have O-ROM capabilities; therefore, it could not read the demonstration disk. MOST plans to introduce an MO drive with O-ROM capabilities, as well as an extended cartridge format so you can store 256 MB per disk while maintaining compatibility with the 128-MB format.

Near the top in performance, the AcuOptic-128E came in second in the Directory-Tree Copy and performed competitively in the other tests. While it promises good performance, the lack of support for O-ROM disks and its relatively high price make me hesitate to recommend it. Keep your eyes on MOST, however; its 256-MB extended cartridge drive with O-ROM read capabilities may well be a choice worth investigating.

IBM PS/2 3.5-INCH REWRITABLE OPTICAL DRIVE

Although IBM's optical drive came ready to run on a Micro Channel system, I chose to test it on an ISA bus to keep the comparisons relatively consistent. To that end, I used Corel Systems' Corel LS2000 8-bit SCSI adapter and CorelDriver 2.20 software.

IBM's documentation was, well, IBMish, and includes, in typically terse style, all the instructions you need to get the drive up and running on a PS/2 system. The Corel documentation, however, is so abundantly detailed that even relatively inexperienced users won't have too much trouble getting up and running.

The slowest of the MO drives I tested, the IBM drive scores well for supporting O-ROM, as does the Corel package for implementing that support in its drivers. Cross-media compatibility is another issue, however, and like the rest, the Corel-driven, IBM-formatted disk was not readable by any of the other controller/driver packages.

MICRONET TECHNOLOGY MO-128/DOS

The MicroNet MO-128/DOS brings a Sony CM-301 drive in a grooved fan-cooled plastic case to your desktop for $2240 with the usual read-panel power, SCSI, and address selectors, and the standard front-panel LEDs and ejection options. Rounding out the package is an NCR-based 16-bit SCSI adapter with internal and external SCSI and floppy drive connectors. Two banks of DIP switches and a couple of jumper blocks allow you to configure the memory and port address, floppy drive options, SCSI ID, parity, and negotiation. You're advised to disable the ROM BIOS if you choose to install the controller as a secondary device.

The MicroNet software consists of Adaptec's advanced SCSI protocol interface (ASPI) driver and disk utility package. AFDISK delivers a comprehensive suite of disk-manipulation and diagnostic utilities under a well-designed and easy-to-use interface. The documentation is

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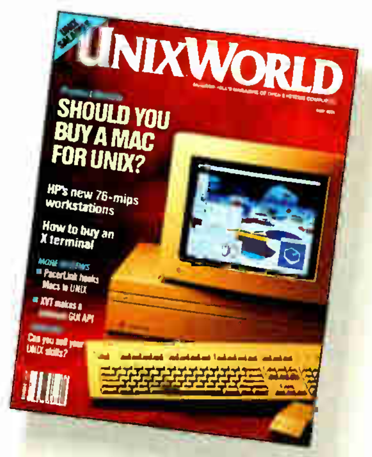

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clear and thorough.

The least expensive of the drives I looked at, the MO-128/DOS also performed well. It edged out the other drives in the Directory-Tree test and came in second in the File Copy. The main drawback to the MO-128/DOS is the lack of support in the ASPI driver for O-ROM disks. Should this change, it would rate a higher recommendation.

PINNACLE MICRO REO-130S

Pinnacle Micro's REO-130S package was the best-thought-out bundle I received. In addition to the 16-bit Western Digital 7000-Fasst controller, REO-130S drive, terminator, cable, Columbia Software's SST software, and media, I received a three-ring binder crammed full of documentation, teal rubber feet to mount the drive vertically, black rubber feet for horizontal positioning, an emergency eject plunger, and an additional REO-130S enamel decal.

The REO-130S is a Sony CM-301 MO drive housed in an attractive small-footprint case that can sit either horizontally or vertically on your desk. The case has two SCSI connectors, a power plug, and a switch, and push-button SCSI ID selection in the rear. Power LED, drive LED, manual-eject, and automatic-eject mechanisms are in the front. The enclosure has no fan.

Priced at a reasonable $2195 for the full external kit, the REO-130S has a good price/performance rating, but thanks to the Columbia Software/Western Digital controller bundle, it rates poorly on compatibility, failing to read either the O-ROM disk or any of the disks formatted in the other drives. Pinnacle Micro says it will supply the Adaptec controller on request at the same price. This combination overcomes many of the compatibility problems.

To say that the REO-130S's documentation and utilities are thorough would be an understatement. The three-ring binder holds detailed instructions for installing both types of Fasst controller that Pinnacle Micro sells, setting up the drive, and detailed instructions for setting up under DOS, Windows, OS/2, and several flavors of Unix. The four "readme" dotted software disks contain all the drivers that you'll ever need for the Fasst card, as well as a disk of utilities in Unix format.

The REO-130S scored near the top in the benchmark tests, coming in first in the File Copy and third in the Directory-Tree Copy. What I really like about this product is the overall finesse of its total package. It is one of my top recommendations.

Go for Compatibility

To buy or not to buy; that is the question. Is it better to suffer from incompatibility or to wait until media interchangeability hits the market? This is a difficult question to address. While it seems extremely likely that optical media can achieve true media-level compatibility, the question is, when?

According to most manufacturers, the next generation of MO drives should add a great deal of functionality. But that's six to 12 months away, an eternity in the personal computer world.

In the meantime, the existing products are convenient, they provide interchangeable, medium-size data storage, and they promise superb performance for an MO-based drive. And what is more important, the pricing, while still rather high, is at an acceptable level to justify the equipment.

If you need large-capacity removable storage, a 3½-inch MO drive is going to make your life a whole lot easier. There's no need to wait for the next generation; the technology is mature now, and the advantages it promises are worth the investment.

This leaves me with a qualified recommendation. If you want the O-ROM capability—the key to keeping the drive from becoming obsolete within a few months—I recommend that you buy a Sony-based mechanism and an Adaptec ASPI. Virtually all the vendors in this roundup will sell you an Adaptec SCSI kit if you ask for it, and I urge you to ask for it. The second best bet would be to get the Corel SCSI package—bearing in mind, of course, that, like the Adaptec and Sony solutions, it locks you into Corel for compatibility.

Of the drives I looked at, the Sony-based drives turned in the best performance. Of these, my vote goes to Pinnacle Micro's REO-130S when teamed up with the Adaptec controller. In terms of performance, documentation, and fit and finish, this drive is the best overall choice from this group. ■

David A. Harvey is a Houston-based computer journalist who specializes in multimedia and optical issues. You can reach him on BIX as "daharvey."

COMPANY INFORMATION

Acumen Computer Systems, Inc.
(AcuOptic 128-E internal, $2795)
(AcuOptic 128-E external, $2995)
1887 Business Center Dr.,
Suite 4A
San Bernardino, CA 92408
(714) 386-7737
fax: (714) 386-7740
Circle 1224 on Inquiry Card.

IBM Corp.
(IBM PS/2 3.5-inch Rewritable Optical Drive internal, $1795;
as reviewed, $2155)
101 Paragon Dr.
Montvale, NJ 06745
(800) 426-2468
Circle 1225 on Inquiry Card.

MicroNet Technology, Inc.
(MO-128/DOS, $2240)
20 Mason
Irvine, CA 92718
(714) 837-6033
fax: (714) 837-1164
Circle 1226 on Inquiry Card.

Pinnacle Micro
(REO-130S internal, $1995)
(REO-130S external, $2195)
19 Technology Dr.
Irvine, CA 92718
(800) 553-7070
(714) 727-3300
fax: (714) 727-1913
Circle 1227 on Inquiry Card.

Sony Corp. of America
(RMO-S350, $2295)
Computer Peripheral Products Co.
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San Jose, CA 95134
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SYSTEM

Fast Fifties: Three 486/50 Systems Redefine PC Performance

STEVE APIKI

Designing around Intel's 486/50 processor is sophisticated enough that relatively few PC and system board manufacturers have delivered 50-MHz machines. That makes the systems from Atronics, Compaq, and Dell—three of the first to ship—especially significant.

These 486/50s represent the fastest Intel-based systems you can buy. But while all three are built on the same processor, they present different strengths. Atronics has built a fast system for an outstanding price. Compaq has taken the high road, besting the others on performance but demanding a premium price. And Dell has staked out the middle ground, delivering a fast, well-built, and well-documented system at a price that lies between those of its two competitors.

I reviewed each system in a standard configuration, appropriate for a single-user Windows machine or Unix workstation: 8 MB of RAM, a desktop case, VGA or Super VGA video, and a workstation hard drive. The most significant difference in configuration is that the Compaq system came with a 340-MB hard drive while the others came with drives closer to 100 MB (see the table).

Comparing Performance

Of course, no matter what the configuration, computing at breakneck speed is what 486/50 workstations are all about. I ran each machine through BYTE's exhaustive performance benchmark suite; the results of each test are graphed in the figure. Keep your perspective when comparing the performance of these systems: The Atronics ATI-486/50's last-place score on our CPU benchmark represents a system almost 1½ times as fast as a 33-MHz 386.

Low-level benchmarks, designed to isolate the performance of different subsystems, produced the most interesting results. BYTE's CPU test rated the Compaq Deskpro 486/50L's cache/memory architecture best, with the Dell PowerLine 450DE system a distant second but still considerably faster than the ATI-486/50. The Deskpro's faster 340-MB

Three of the fastest: The Compaq Deskpro 486/50L (left), the Atronics ATI-486/50 (center), and the Dell PowerLine 450DE (right) are the most high-powered Intel-based systems yet, but the Deskpro easily outperforms the others.

BYTE ACTION SUMMARY

- **WHAT 50-MHZ 486 SYSTEMS ARE**
  These are systems built on Intel's fastest processor to date, the 486/50.

- **LIKES**
  Each system offers unprecedented performance; Compaq's Deskpro 486/50L is outstanding even in this fast group.

- **DISLIKES**
  Atronics' ATI-486/50 is flimsily put together; the faster performance of the Deskpro 486/50L is available only at a drastically steeper price.

- **RECOMMENDATIONS**
  If price is a top priority, choose the ATI-486/50; if you need top performance, choose the Deskpro 486/50L. For most applications, Dell's PowerLine 450DE strikes a good balance between low cost and high performance.

- **PRICE**
  Atronics ATI-486/50, $2932
  Compaq Deskpro 486/50L, $12,999
  Dell PowerLine 450DE, $5548

- **FOR MORE INFORMATION**

Atronics International, Inc.
45635 North Port Loop E
Fremont, CA 94538
(510) 656-8400
fax: (510) 656-8560
Circle 1221 on Inquiry Card.

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SYSTEM CONFIGURATION AS TESTED

For its price, the ATI-486/50 offers an outstanding repertoire of features. The key to the more expensive Deskpro's high performance is its 256-KB write-back cache, built with Intel's 82495DX cache controller.

	Atronics ATI-486/50	Compaq Deskpro 486/50L	Dell PowerLine 450DE
Price (as tested)	$2932	$12,999	$5548
Dimensions (inches; W × H × D)	7.25 × 13.25 × 16.25	19.2 × 6.5 × 17.7	16.25 × 6.25 × 16.25
Processor	50-MHz 486	50-MHz 486	50-MHz 486
RAM (as tested; MB)	8	8	8
RAM (maximum on-board; MB)	32	104	48
Cache			
Size (KB)	256	256	128
Minimum/maximum (KB)	64/256	256/256	128/128
Type	Direct-mapped/write-back	Two-way set-associative/ write-back	Direct-mapped/write-through
Expansion slots	Seven 16-bit, one 8-bit	Seven EISA	Six EISA
Hard drive	Conner	Conner	Quantum Pro
Capacity (MB)	120	340	100
Average seek time (ms)	25.5	12	17
Interface	IDE	IDE	IDE
Drive controller	Informtech	Compaq	Dell
Floppy drives (MB)	1.2/1.44	1.2/1.44	1.2/1.44
Drive bays	Five	Four	Four
Serial ports	9-pin/25-pin	Two 9-pin	Two 9-pin
Other ports	Game	Mouse	Mouse
Video controller			
Video RAM	1 MB	512 KB	1 MB
Maximum resolution	1024 × 768 × 256	640 × 480 × 256	1024 × 768 × 56
Power supply (W)	220	300	224
Distribution channel	Direct	Dealer	Direct/retail
Warranty (years)	One	One	One

drive stood out on low-level disk tests, but the PowerLine's quick 120-MB Quantum drive proved surprisingly fast. Dell's innovative graphics design pushed the PowerLine past the other systems on video benchmarks.

The Deskpro's cache/memory system proved to be the deciding factor on DOS and Windows application tests, where it outran the others. The Deskpro handled compute-intensive applications such as spreadsheets especially well. Naturally, its faster drive also gave it an edge, especially in word processing and DOS development tests. I would expect to see the Dell and Atronics systems perform nearly as well as the Deskpro at these tasks if equipped with drives of similar speed.

BYTE's Unix benchmarks rated the Dell and Compaq systems nearly equivalent, but that's mostly because of the Deskpro's faster drive. Dell's implementation of Unix System V release 4 gave the PowerLine a superior score on half of the tests and an excellent overall Unix score.

Atronics ATI-486/50

Atronics is a well-established motherboard manufacturer with a reputation for designing good system boards. The ATI-486/50 is a mini-tower unit built around the company's ATI-486/B2 motherboard. At $2932, this system is by far the least expensive of the three presented here.

The motherboard supports the processor and 64 or 256 KB of write-back second-level cache. It accepts eight standard SIMMs; mine was filled with 1-MB SIMMs for a total of 8 MB, but you can expand memory on-board up to 32 MB with 4-MB SIMMs. The system also has a proprietary 32-bit slot for proprietary memory-card upgrades.

Surprisingly, Atronics has built this high-performance processing system onto an ISA motherboard. While ISA components are far more common today than EISA or Micro Channel add-ins, down the road the 16-bit bus will limit the speed of peripherals you can attach to the ATI-486/50. The system includes six 16-bit slots, an 8-bit slot, and the proprietary memory card slot, which also doubles as standard ISA. An IDE controller and a 16-bit Super VGA card took up two of the sockets in my test machine.

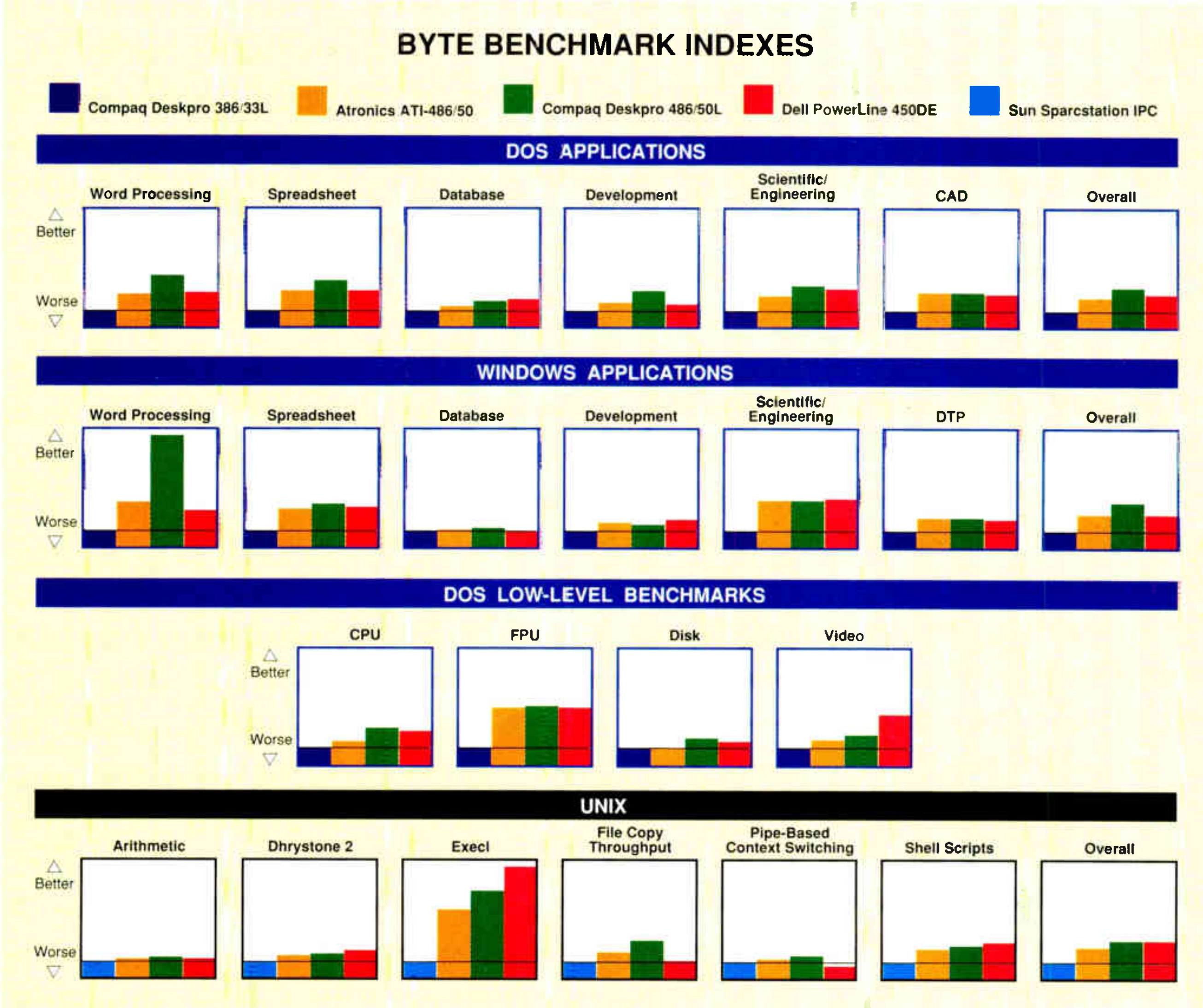
The ATI-486/50 didn't fare very well against the Dell and Compaq 486/50s, especially on our low-level benchmarks. However, it held its own on DOS and Windows application tests, with scores similar to those of the PowerLine.

Unfortunately, the ATI-486/50 is lacking in finish and attention to detail. For example, loose connections on the video card led to an occasional loss of some signals. The mini-tower case is flimsily constructed, and interior components are hard to reach. Worst of all, the only documentation included with the system is a motherboard manual.

Compaq Deskpro 486/50L

Compaq's expertise in building high-performance systems shows in its design of the Deskpro 486/50L. The system is very fast, well constructed, and designed with an eye toward expandability. For organizations that view cost as a secondary concern, the Deskpro 486/50L is an easy choice; for the rest of us, its $12,999 price tag will prove daunting.

At the heart of this screamer is a processor-memory architecture tuned for high performance. The 50-MHz 486 CPU is matched with an Intel 82495DX cache controller and 82490DX cache RAM, components that are specifically



All results are indexed, and higher numbers indicate better performance. For each index in the DOS and Windows tests, a Compaq Deskpro 386/33L running Compaq DOS 5.0 and Windows 3.0 = 1. For each index in the Unix tests, a Sun Sparcstation IPC = 1. The overall index is the average index of the individual tests.

The BYTE low-level benchmark suite identifies relative performance at the hardware level, breaking down performance by system component. The results of these tests can help you to identify the relative performance of a given subsystem and to determine where performance bottlenecks may lie. For a complete description of these tests, see "BYTE's New Benchmarks: New Looks, New Numbers," August 1990 BYTE. The BYTE low-level benchmarks, version 2.2, are available in the byte.bmarks conference on BIX, or you can contact BYTE directly.

BYTE's application performance suite measures the performance you can expect to see running a given application category under a given operating environment. We test under two environments, DOS 5.0 and Windows 3.0. We test six application categories for each environment, running test scripts using the following programs: Word Processing: WordPerfect 5.1 and Lotus Ami Pro 2.0; Spreadsheet: Lotus 1-2-3 release 3.1+ and Microsoft Excel 3.0a; Database: Software Publishing Superbase 4 1.3 and Ashton-Tate dBase IV; Development: Borland Turbo Pascal for Windows and Microsoft C 6.0; Scientific/Engineering: MathSoft MathCAD for Windows 3.0, The MathWorks MatLab 3.5k, and Computing Resource Center Biturbo Stata 2.1; CAD: Autodesk AutoCAD release 11; and Desktop Publishing: Aldus PageMaker 4.0. The data files and test scripts are available from BYTE.

Our Unix tests show relative performance for double-precision arithmetic, the Dhrystone 2 benchmark, spawning a process (execl()), file copy throughput (in 5 seconds), pipe-based context switching, and running a shell script with eight concurrent scripts running. Unix benchmarks are available on Usenet, from Demolink, in the listings area on BIX, or on disk

Benchmarks show surprising variation in 486/50 performance. While the Deskpro 486/50L scored best on CPU-oriented tests, the PowerLine 450DE did best on graphics. Dell's version of Unix System V release 4 gave the PowerLine an edge on our Unix tests; the other two machines were tested with SCO Unix System V 3.2.2.

designed to enhance 486 performance. The 82495DX provides write-back access to memory through a 256-KB two-way set-associative cache. The cache subsystem is backed up by interleaved fast-page memory, which reduces average wait states on cache misses.

Although Atronics and Dell provide second-level caches on their systems, the Deskpro's design proved fastest on our tests. Besides earning the highest CPU benchmark score the BYTE Lab has measured, the Deskpro proved fastest overall on our application-level tests.

Compaq equipped its system with a fast (12-millisecond) 340-MB IDE hard drive, which gave it a noticeable boost over the other systems on some application and Unix tests. A Deskpro with a 19-ms 120-MB drive, which more closely matches the other two systems' configurations, sells for $11,299.

The Deskpro 486/50L is built for expansion, with seven EISA slots and room for over 100 MB of system RAM on the motherboard. IDE controller and I/O ports are built in; the only slot filled in the standard configuration holds a 16-bit VGA card.

The system is very solidly built, enclosed in a case similar to that of earlier Deskpro models. I didn't encounter any problems with the system during the month-long review process, when the Deskpro served alternately as LAN Manager server, Unix host, and platform for Windows applications, including Ami Pro and Excel.

Dell PowerLine 450DE

Although 50 MHz defines a new performance standard that will likely last for some time, it never hurts to plan ahead. Dell's PowerLine 450DE is alone among these systems in offering a modular design that allows for future processor upgrades. In the configuration I tested, with a 50-MHz 486 and 8 MB of system memory, the PowerLine 450DE sells for $5548.

The processor fits on a card that plugs into a proprietary slot on the motherboard. The 486 shares the card with the cache controller, 128 KB of cache RAM, and the system clock crystal. All speed-sensitive system components are thus isolated on this card, so you can swap in other modules as your needs change.

System memory resides on the motherboard. My review system came with 8 MB of 60-nanosecond fast-page DRAMs, but you can expand the PowerLine's memory up to 48 MB. A Dell-designed memory controller application-specific IC runs the memory bus, enhancing performance. The 128-KB cache, backed up with this fast memory architecture, gave the PowerLine good benchmark results, although the Deskpro was faster on the CPU test and in most applications.

The highly integrated motherboard also includes an IDE-controller, I/O hardware, and Super VGA (1024- by 768-pixel) video with 1 MB of video RAM. This leaves all six EISA sockets open for expansion.

The PowerLine 450DE's performance on the video benchmarks was outstanding. As with most systems, video BIOS is shadowed to system RAM for improved performance. Dell's proprietary graphics architecture achieves fast access to video memory. This gave the PowerLine the top score on the video benchmarks and made it very responsive in graphics-intensive applications.

Best of the Fifties

Fifty-megahertz systems will set the performance standard for quite some time. Whichever system you choose, make sure that it matches your requirements for price, performance, and future expansion.

While the overall performance crown belongs to Compaq, the Deskpro's price will put it out of reach for all but the most demanding users. The Atronics ATI-486/50 has an outstanding price, but it's not quite as fast and not as well constructed as the other two systems.

Dell's well-built, high-performance PowerLine 450DE balances the extremes of the Atronics and Compaq systems. It's an excellent choice if money, speed, expansion capability, and solid construction are all strong concerns. ■

Steve Apiki is a BYTE technical editor with a B.S.E.E. from Rensselaer Polytechnic Institute. You can contact him on BIX as "apiki."

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SOFTWARE

Edit Video at Your Desk

TOM YAGER

StudioMaster Pro's user interface shows one scene of an edit session at a time. The VCR control is in the lower left.

BYTE ACTION SUMMARY

WHAT STUDIOMASTER PRO IS
Mac-based video-editing software for use with professional video decks and controllers.

LIKES
Ease of use; frame-accurate edits; integrated transitional effects.

DISLIKES
Inability to scale graphics; one set of controls for two VCRs; sluggish interface performance.

RECOMMENDATIONS
An excellent editing system for any desktop video producer who wants, and can afford, professional quality.

PRICE
$1495

FOR MORE INFORMATION
AT&T Graphics Software Labs
3520 Commerce Crossing
Indianapolis, IN 46240
(317) 844-4364
fax: (317) 575-0649

Circle 1230 on Inquiry Card.

Desktop video production seems to be following the same path as desktop publishing, albeit more slowly: transferring power from the well-heeled, privileged few to a much broader constituency. AT&T Graphics Software Labs, a respected veteran of the video business (and a multimedia pioneer), takes a step in this direction with StudioMaster Pro, a software package that helps turn a Macintosh into a professional videotape editing system.

With StudioMaster Pro and some required additional hardware, anyone with raw video footage and some good ideas can do work that previously had to be done by a production house. The system isn't quite a "studio in a can," but it has most of the elements you'll need to produce tapes of a quality suitable for public viewing. In fact, with a software cost of $1495, this is the most affordable system you'll find for easy, professional-quality video editing.

The Hard Side

In addition to the software, you'll need a pair of video decks—one player and one recorder—and a board to control them. For the latter, StudioMaster Pro supports the internal Diaquest DQ-Animaq card, which the BYTE Multimedia Lab based this review on, and the external BCD 5000 unit. The DQ-Animaq card controls two professional/industrial video decks through intelligent RS-422 interfaces. For video, the Multimedia Lab used a Panasonic AG-7750 recorder and an AG-7650 player. These are Super VHS decks built for demanding professional use. AT&T Graphics Software Labs also sells a version of StudioMaster Pro, simply called StudioMaster, that works with less expensive decks like the Panasonic AG-1960. But the AG-7750 and AG-7650 are typical of mid-priced decks that produce professional-quality results. And of course, you'll need TV monitors. I recommend two, but you can often get by with one.

Combining StudioMaster Pro with the DQ-Animaq and the industrial decks gives you several advantages over editing systems built around less expensive gear. First, you gain accuracy. Both of the Multimedia Lab's video decks have the optional time-code boards installed, so the position of every frame on the tape is precisely marked. Using time code, StudioMaster Pro can cut your edits in and out with the greatest possible accuracy—right down to the exact frame.

The second advantage is that, because of the precision tape transport in the decks and the high-speed serial interface to the Diaquest controller, edits take much less time than with consumer gear that lacks these features. And finally, it doesn't take a videophile to notice the difference in quality between a consumer VCR and a professional video deck. Even using the same video format, the professional equipment consistently creates better-looking tapes.

The final part of the special hardware mix is the Truevision NuVista+. This is a display card with video I/O built in. The NuVista+ can take in a video signal, mix it with Macintosh graphics, and output the combined graphics and video. Its output is recordable, and that's precisely how StudioMaster Pro does its video processing. The playback deck connects to the NuVista+'s video input, while the record deck connects to the board's video output.

Plug In, Turn On

It takes a handful of connections to get StudioMaster Pro and all its hardware components working together. I used two RS-422 control cables (one each to the player and the recorder), two video cables (one in from the player, one out to the recorder), one sync cable, and a pair of audio cables. The sync cable helps the Diaquest controller maintain frame accuracy, and the audio cables are simply run from the player to the recorder.

StudioMaster Pro requires HyperCard 2.1. If you try to run it on anything prior to version 2.1, you'll experience some errors. I had no trouble installing StudioMaster Pro on the Multimedia Lab's Mac IIci. The HyperCard interface means that this application doesn't break any speed records; there are times when you will have to spend several seconds waiting through some inexplicable delay. These delays don't appear during the time-sensitive portions of a recording session, however.

The main display is very well laid out (see the screen), and operation is simple. The interface to the VCRs is a group of buttons set in a VCR-like drawing. A window on this virtual VCR shows the current location (in time code), and a short pull-down menu lets you choose between the playback and record decks. This is a bit odd; since StudioMaster Pro is limited to two decks, I would have preferred two constant sets of controls. However, it turns out not to be much of a hassle, since during most edit sessions, you tend to control the player much more than the recorder.

An individual scene comprises an in point and an out point, and StudioMaster Pro lets you use the VCR controls to locate them. If you prefer, or if you need to tune the in or out point of a few frames, you can modify the on-screen time codes manually. You can also set the location where recording will begin when you start your edit. This lets you modify an existing tape or ensure that previously recorded material is *not* modified.

When you mark the in and out points, StudioMaster Pro uses the NuVista+ to capture video freeze frames, which are scaled down and shown as part of the scene display. You then move from one scene to the next, maintaining them in sequence until your entire video, or the segment you're working on, is represented by a group of scenes. Just the push of a button sends the entire edit to the recorder.

The degree of control this program has over the video decks is impressive. In addition to the VCR controls, the forward and reverse jog and shuttle (frame advance and variable-speed play, respectively) speeds can be modified to your taste. For each scene, you can select any of the video, audio 1, and audio 2 channels; it's possible to have a scene that records only audio or video and leaves the other alone.

New Vistas

The NuVista+ adds considerably to StudioMaster Pro's capabilities. In addition to specifying tape segments in a scene, you can select Macintosh graphics files (created elsewhere) that will be recorded for a specified duration. When a graphics file is displayed, it can either take up the entire screen or be overlaid on top of playback video for titling and other effects. The graphics have to be created for the resolution your NuVista+ is set to; StudioMaster Pro won't scale the graphics for you.

The NuVista+ also gives StudioMaster Pro some limited, but tasteful, transitional special effects, including wipes, mosaics, and pushes. You can't produce all the special effects that you can with the Video Toaster (See "Newtek's Video Toaster Makes Professional Video Affordable," March 1991 BYTE), but they are interesting enough to break up the monotony of one dry cut after another.

Since there is only one playback source, it's impossible to make a smooth transition, such as a fade, between one scene on the tape and the next—the footage you're trying to make a transition from has already been recorded. StudioMaster Pro works around this by digitizing the last frame of video preceding the transition and then making a transition from that frozen frame to the live video playback. The resulting transition looks smooth, even though it isn't applied to a moving image. You can see the image freeze if you watch, but since all the video runs through the NuVista+, the frozen image is perfectly aligned with the playback video.

The Final Edit

StudioMaster Pro is the only professional-level editing package I can confidently recommend to those who are not experienced with video. It's not without its drawbacks, with HyperCard-sluggish performance being among them, but it's still a far cry from one-step-at-a-time manual-edit controllers and unwieldy Edit Decision List systems.

StudioMaster Pro, along with the required hardware and some Macintosh graphics software, may be all you need to start producing your own professional-looking videos. ■

Tom Yager is the director of BYTE's Multimedia Lab. He can be reached on BIX as "tyager" and on the Internet at tyager@bytepb.byte.com.

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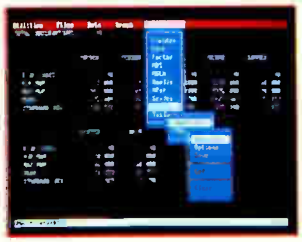



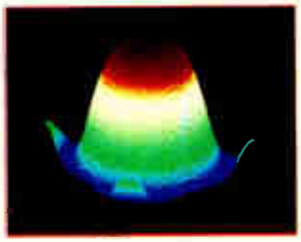

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Statistics Basic statistics, frequencies, *t*-tests, post-hoc tests ▪ Multi way crosstabs with log-linear modeling, association coefficients, PRE statistics, Mantel-Haenszel, asymptotic standard errors ▪ Nonparametric statistics (sign, runs, Wilcoxon, Kruskal-Wallis, Friedman two-way ANOVA, Mann-Whitney U, Kolmogorov-Smirnov, Lilliefors, Kendall coefficient of concordance) ▪ Pairwise/listwise deletion of missing values, Pearson correlation, SSCP, covariance, Spearman, Gamma, Kendall Tau, Euclidean distances, binary similarities ▪ Linear, polynomial, multiple, stepwise, weighted regression with extended diagnostics ▪ Multivariate general linear model includes multi way ANOVA, ANCOVA, MANOVA, repeated measures, canonical correlation ▪ Principal components, factor analysis, rotations, components scores ▪ Multidimensional scaling ▪ Multiple and canonical discriminant analysis, Bayesian classification ▪ Cluster analysis (hierarchical, single, average, complete, median, centroid linkage, k-means, cases, variables) ▪ Time series (smoothers, exponential smoothing, seasonal and nonseasonal ARIMA, ACF, PACF, CCF, transformations, Fourier analysis) ▪ Nonlinear estimation (nonlinear regression, maximum likelihood estimation, and more).

Graphics Overlay plots ▪ Drivers for most graphics devices ▪ *Two-dimensional:* Error bars ▪ Scatterplots ▪ Line and vector graphs ▪ Vector, dot, bubble and quantile plots ▪ Bar graphs (single, multiple, stacked, range) ▪ Box plots (single and grouped) ▪ Stem-and-leaf diagrams ▪ Linear, quadratic, step, spline, polynomial, LOWESS, exponential smoothing ▪ Confidence intervals and ellipses (any alpha value) ▪ Smooth mathematical functions ▪ Rectangular or polar coordinates ▪ Log and power scales ▪ ANOVA interaction plots ▪ Histograms (regular, cumulative, fuzzy) ▪ Stripe and jitter plots ▪ Gaussian histogram smoothing ▪ Scatterplot matrices ▪ Voronoi tesselations ▪ Minimum spanning tree ▪ Maps with geographic projections (U.S. state boundary file included, county and world boundary files available) ▪ Chernoff faces ▪ Star plots ▪ Fourier plots ▪ Pie charts ▪ Contour plots on regularly and irregularly spaced points ▪ Control charts and limits ▪ *Three-dimensional:* Data plots ▪ Smooth function plots ▪ Vector plots ▪ Linear, quadratic, spline, least squares surface smoothing ▪ Typefaces that print in perspective.

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SOFTWARE

What You See Is What You Solve: Mathematica and MathCAD for Windows

NICHOLAS BARAN

Mathematica and MathCAD represent two different categories of math processing software. Mathematica, which is designed more for the higher end of the scientific community (e.g., theoretical physics), is a full-fledged development environment with a built-in programming language as well as interactive capabilities. MathCAD is not so much a theoretician's tool as it is an interactive notebook for math calculations. Mathematica is more powerful than MathCAD, but it's also much more expensive ($995 versus $495).

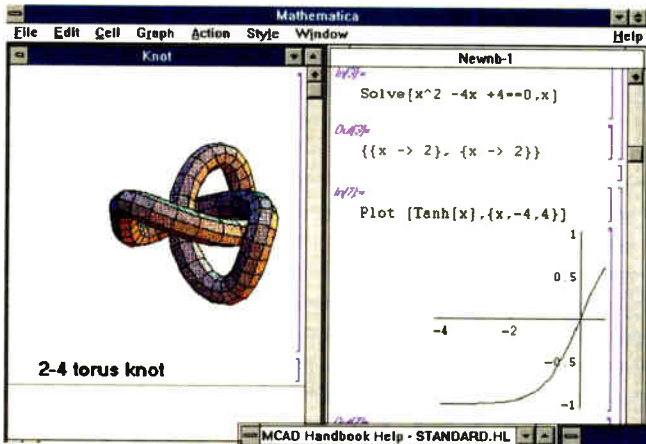

Photo 1: *Two Mathematica windows. On the left is a notebook page for generating a torus knot. On the right is an interactive session in which you type in a problem and get back an answer.*

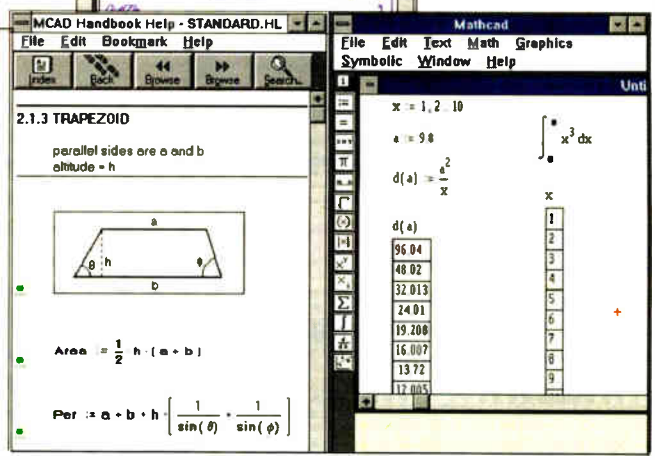

Photo 2: *The left window shows a MathCAD handbook. The right window shows an interactive MathCAD session, in which you enter equations that the program then solves. Note the palette of math functions.*

Mathematica 2.0

Wolfram Research's Mathematica is one of the luxury vehicles of math processing on personal computers and workstations. Besides working as a numeric and symbolic calculator, Mathematica can be used as a high-level programming language, a modeling and analysis tool, and a computation server for other programs, such as spreadsheets. With the new Windows version, Mathematica runs on virtually every major hardware platform, including the Mac and Unix systems.

The program is divided into a kernel, which does the computation, and the front end, which provides the user interface and input capabilities. The kernel is basically the same on all hardware platforms; the front end varies according to the graphics support of the host system. On GUI machines, Mathematica uses a "notebook interface," in which you can interactively execute calculations. On the pages of these notebooks in the Windows version, you can mix formulas, graphics, sound, and animation.

Mathematica can generate attractive graphics, including contour and three-dimensional plots. Moreover, with the program's good text-processing capabilities, you can extensively annotate documents. Since Mathematica uses PostScript for rendering graphics, there is a high level of portability of graphical images between platforms. I ran a notebook from the Windows version, without modification, on a Next computer. I could also open a notebook from the Next version and use it in the Windows version. The portability of Mathematica between graphical environments is one of its strong points.

Many math programs use symbols such as the square root radical and integral in the on-screen equation (as you'll see, MathCAD uses symbols). The drawback to this is that symbols make the program dependent on the graphical interface of the host system, since there are no standards for putting math symbols on the screen. Mathematica is so portable because it uses a library of English-like commands for executing mathematical operations.

A Mathematica equation is stored and can be imported or exported in ASCII format, which is highly portable. (A MathCAD equation, by comparison, can be exported only as a bit-mapped image, which is not very portable except for display purposes.)

Mathematica is based on an interpreted Lisp-like programming language. Version 2.0 incorporates more than 840 functions, covering virtually every conceivable math operation. The language also includes database and list capabilities for generating complex plots or statistical analyses, for example.

You can use the language either interactively—simply by typing in a command and getting back an answer—or by setting up a Mathematica program, using variables, loops, conditional statements, and so forth. The example in photo 1 shows a screen of two windows with a notebook for generating a torus knot on the left and an interactive session on the right. To get a feel for what the Mathematica programming language looks like, see listing 1.

continued

Because of its portability and powerful programming language, Mathematica has gained a substantial following in a variety of disciplines. Its adaptability to different applications is evident from the large number of software add-ons, called Mathematica packages. These are basically Mathematica programs written to perform a specific task. Mathematica 2.0 comes with packages for linear algebra, number theory, statistics, geometry, and assorted operations. Others are available through Mathematica user groups and BBSes.

The Windows version of Mathematica is much like the Next and Macintosh versions, so if you're already using one of those, you'll have no problem getting up to speed under Windows. Mathematica must run in enhanced mode, taking advantage of the virtual memory capability. The more memory your system has, the better Mathematica's performance.

The current version is a bit unstable. Mathematica crashed unexpectedly as I loaded a sample notebook, reporting an out-of-memory error, although this was the only Mathematica application running and no other Windows applications were loaded. On one other occasion, Mathematica announced an application error and took me out to the C> prompt while I was executing some interactive commands. Wolfram Research has acknowledged that there are still some bugs in the Windows version.

Mathematica is a powerful and complex program for solving complex problems. Except for executing basic computations, mastering it requires a serious commitment from the user. To really learn it, you need to work through Stephen Wolfram's book *Mathematica* while seated at your computer. Be prepared to spend some serious time if you want to learn Mathematica.

On the other hand, if you have to solve the sorts of problems that physicists and other scientists and researchers encounter, Mathematica makes your work much easier. Until the Windows version of Maple V comes out (see the text box "Another Hard-Core Problem Solver" on page 266), Mathematica has no competition on the PC.

Mathematica is comprehensive and elegant and can solve just about any numeric or symbolic problem you're likely to encounter. Its file portability between different machines is a big plus, and the widespread user support and proliferation of Mathematica packages are attractive. Right now this is the Cadillac of math processors for Windows.

MathCAD 3.0

Mathematica is certainly a hard act to follow, and MathCAD doesn't try. It's a different kind of math program—a calculator replacement geared toward engineers, researchers, and students who need to execute symbolic calculations and don't need a programming language.

With version 3.0, MathSoft has made a major addition to MathCAD: The

Listing 1: *To give you a feel for the Mathematica programming language, here is a sample of code for calculating prime numbers.*

```
MyPrimePi::usage = "MyPrimePi[x] returns the number of primes <= x."

Attributes[MyPrimePi] = {Listable}

Begin["'Private'"]

MyPrimePi[x_] := 0 /; x < 2

MyPrimePi[x_] :=
   Module[{li, n0, n1, m, nx = N[x]},
   li = LogIntegral[nx];
   n0 = Floor[li - LogIntegral[Sqrt[nx]]];
   n1 = Ceiling[li];
   While[ n1 - n0 > 1,
  m = Floor[(n0+n1)/2];            (* midpoint *)

   If[ Prime[m] <= nx, n0 = m, n1 = m ]
 ];
 n0
   ] /; x >= 2

End[]
```

BYTE ACTION SUMMARY

■ **WHAT MATH PROGRAMS DO**
Mathematica and MathCAD offer powerful computational capabilities for solving math problems interactively.

■ **LIKES**
Mathematica offers high-end calculation tools, a programming language, and portability between platforms. MathCAD is geared toward less complex problems but, with the addition of the Maple symbolic processor, has very strong computational capabilities. Handbooks provide live reference material.

■ **DISLIKES**
The Windows version of Mathematica is a bit unstable, so save your work often. The MathCAD user interface, while slick, can feel clumsy and difficult to use.

■ **RECOMMENDATIONS**
For solving hard-core math problems, Mathematica is the winner under Windows. For a Windows-based calculator/engineer's notebook with powerful computation tools, try MathCAD.

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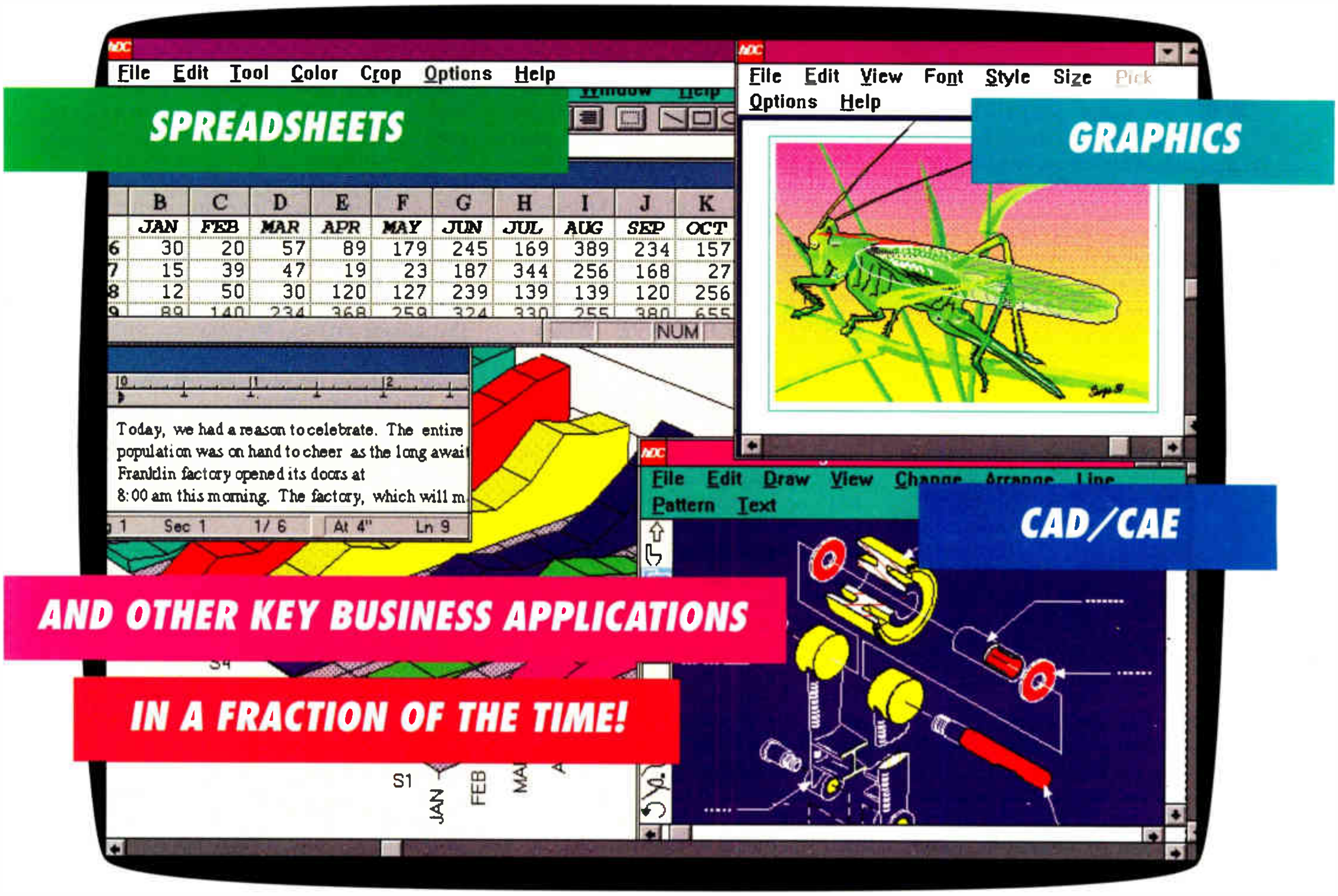

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Another Hard-Core Problem Solver

D. Barker

While Mathematica has gotten most of the press and publicity, another program has quietly gained a strong following in the fields of higher mathematics. Maple V from Waterloo Maple Software is designed, like Mathematica, for solving hard-core symbolic and numeric problems. The fact that Maple V has been picked as the symbolic processing engine for MathCAD and Speak-EZ is a tribute to the program's capabilities.

While Mathematica usually gets the nod for having better graphics functions and a more elegant interface, users who have tried both programs generally say that Maple V is more powerful when it comes to solving heavy-duty problems.

"Out of the box, Maple V is considerably more powerful than Mathematica," says Marvin Weinstein, a theoretical physicist. Maple V can handle differential forms, has a Newman-Penrose package for general relativity, is familiar with group theory, and can solve nonlinear problems "that Mathematica doesn't touch," he says. Maple V is also faster when working with serious problems, he notes. It does not generally evaluate special functions for complex argument, whereas Mathematica does, Weinstein points out.

Mathematica's programming language is easier to get started with than Maple V's, which Weinstein says is more procedural in nature. Which is better depends on personal preference, users agree.

Maple V is available on just about every computer platform out there, including DOS (a 386 is required), Macintosh, Amiga, Atari ST, most Unix machines, and VMS. It generally costs less than Mathematica; the Mac version, for example, is $450, while Mathematica is $595. The kernel and the function library are the same for each version; the interface varies according to operating environment.

The program has a considerable following at universities, where it is often site-licensed as a computer algebra tool. Maple V is being used in applications ranging from analyzing the biological effects of asbestos fibers to solving problems of quantum mechanics.

Waterloo Maple Software plans to have a version of Maple V out for Windows by the middle of this year. When that edition arrives, Mathematica will no longer be the only third-generation symbolic math package running under the Windows environment.

For more information, contact Waterloo Maple Software, 160 Columbia St. W, Waterloo, Ontario, Canada N2L 3L3; (519) 747-2373; fax: (519) 747-5284.

D. Barker is a BYTE Lab technical editor. You can contact him on BIX as "dbarker."

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company has packaged in a reduced version of Maple, a high-end math program that competes with Mathematica. This program serves as MathCAD's symbolic processor. You load it explicitly from a pull-down menu. With Maple, MathCAD lets you solve equations symbolically (in terms of a variable rather than numerically) using the Symbolic option on the main menu. The symbolic processor includes options for factoring, expanding, and simplifying algebraic equations, differentiation and integration, and matrix operations.

MathCAD uses a worksheet approach, putting an engineer's notebook on the screen. Photo 2 shows a typical MathCAD session. In the left window is a MathCAD handbook. Handbooks can contain equations and data sets for various disciplines, such as electrical engineering, chemistry, and so forth. You can take an equation or formula from a handbook and paste it into your worksheet. In the right window is an interactive session. Note the palette on the first column. There are four palettes with a comprehensive set of math functions, operators, and symbols (you can switch between palettes). As you build an equation in MathCAD, you select items from the palette and insert them into the equation.

Although MathCAD generates nice-looking equations and text, they don't move well to other applications. Equations that are pasted from MathCAD into other Windows programs appear as bit-mapped images. This may not be a problem if you intend to use MathCAD documents in their original format. But if you plan to incorporate MathCAD equations into other documents, the bit-mapped images could be a limitation.

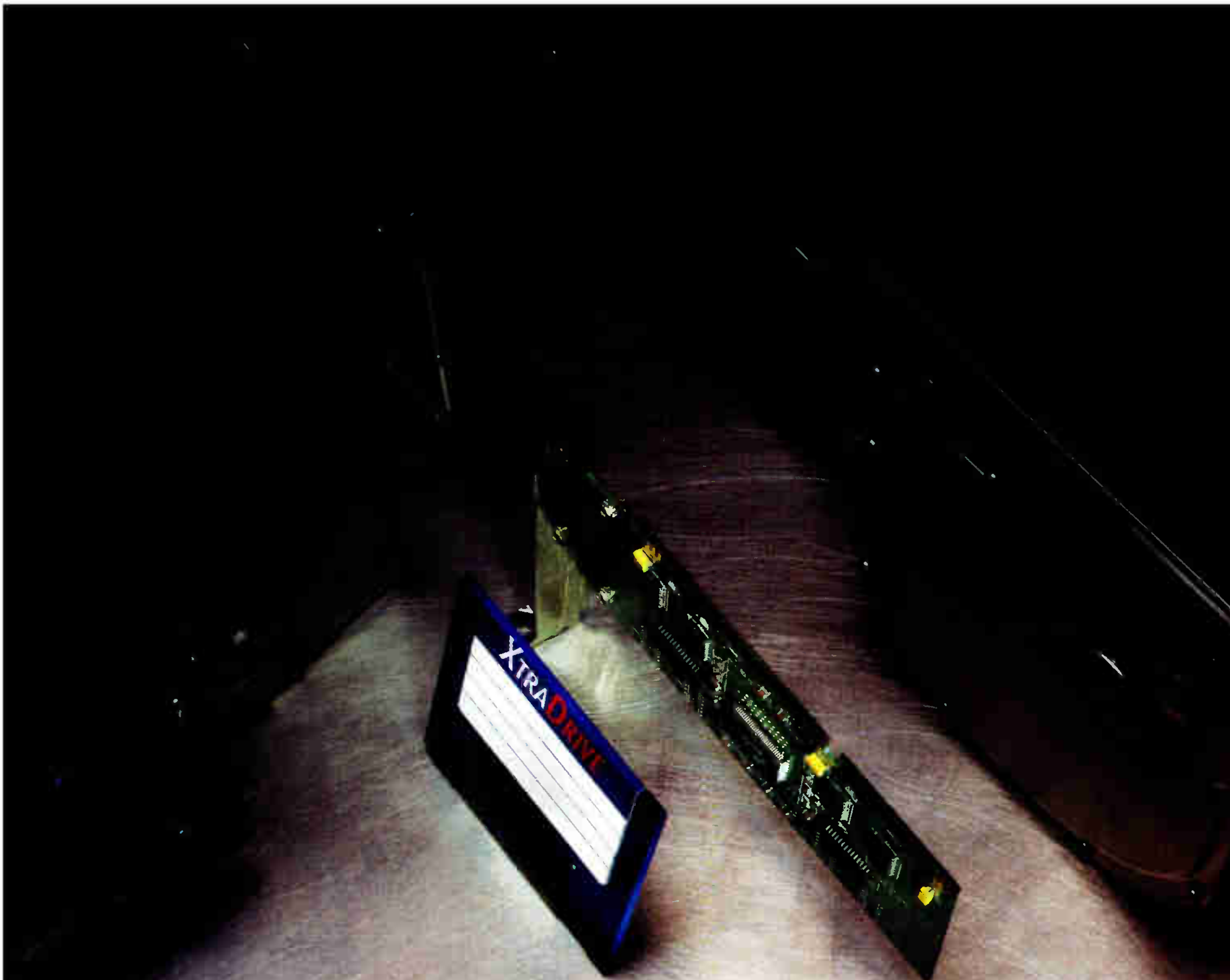
MathCAD has a library of nearly 100 functions (aside from the Maple processor), including statistics, matrices, and numerical integration and differentiation. It also has capabilities for importing data from structured files and lists, making it possible to interface MathCAD with data acquisition or database software. The program has good plotting and graphics capabilities, including contour plots.

My major complaint with MathCAD involves the user interface. As mentioned earlier, MathCAD relies on symbols for setting up equations. Maybe it's just me, but I found myself constantly making mistakes and having to reenter the equation. The equation editor feels clumsy, and I found it easier to erase an equation entirely and start over rather than try to edit an existing equation.

The inflexibility of the equation-entry format is irritating. I could not, for example, enter a variable multiplied by a constant, such as $4x$, without entering a multiplication symbol separating the constant and the variable (i.e., you have to enter $4x$ as $4*x$). When first using the program, I found myself preoccupied with trying to get the equation in the proper format rather than with the mathematics. People who've been using the program for a longer time say you get over that. I find something like Mathematica's English-like equation-entry syntax to be much more intuitive than the symbol system used in MathCAD.

MathCAD 3.0 is a good product if you don't have to swap electronic data between platforms or need extensive programming features. For setting up computational worksheets, or for just plain equation solving on the fly, MathCAD is well worth looking at. You can bet that someday this program will be running on hand-held, pen-based computers. This is the engineer's pocket calculator of the future. ■

Nicholas Baran, a consulting editor for BYTE, is the author of Finite Element Analysis on Microcomputers *(McGraw-Hill, 1988). He is currently coeditor of* Pen-Based Computing, *a newsletter based in Sandpoint, Idaho. You can contact him on BIX as "nickbaran."*



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HARDWARE

Windows Printer Shines in Speed, Resolution

BRADLEY DYCK KLIEWER

My first reaction to the LaserMaster WinPrinter 800 was one of surprise and skepticism. Who needs a printer designed specifically for Microsoft Windows, especially one that requires at least a 386 processor and 8 MB of RAM?

After working with the WinPrinter, I decided that it isn't for everyone. Those who don't need high resolutions or sped-up performance under Windows should choose one of the myriad of other affordable PostScript laser printers on the market. However, Windows users, especially those running desktop publishing applications that need higher than 300-dot-per-inch output, can certainly benefit from LaserMaster's design.

LaserMaster's TurboRes technology enhances the WinPrinter's PostScript fonts and line drawings to an effective resolution of 800 dpi. The print engine runs at 400 dpi, but special laser-modulation techniques improve both the horizontal and vertical effective resolution (see figures 1 and 2). The resulting images are quite impressive (see "Enhancing Laser-Printer Resolution," March BYTE). PostScript language interpretation and font scaling require a great deal of processing power. And the TurboRes algorithms increase the computational needs of the printer.

Among the WinPrinter's unique characteristics is its lack of a built-in processor. The fact that the printer must be used with a 386- or 486-based PC running Windows with 8 MB of RAM may seem unusually demanding, but if you use Windows regularly (especially for desktop publishing applications), you probably already have a system that meets these requirements.

Because the WinPrinter uses your system's processor, memory, and hard disk space for most of its processing functions, it is little more than a shell with an engine. It has no parallel or serial port, but rather a video interface card that sits inside your system unit and sends signals to the printer through a special 37-pin cable. This interface drives the print engine and controls the laser modulation.

This approach bypasses the added costs associated with printer-based microprocessors, memory (both RAM and ROM), and specialized languages. In addition, you can upgrade the WinPrinter's processing power when you move to a more powerful computer system.

The WinPrinter uses a special Windows driver and the host computer's processor for fast, high-resolution printing.

Driver Details

LaserMaster based the WinPrinter and the WinJet, an adapter for the Hewlett-Packard LaserJet, on this approach. The WinJet ($995) adds the features of the WinPrinter to existing LaserJet printers. The WinPrinter includes a 4-page-per-minute Canon engine that operates at either the standard 300-dpi resolution or an enhanced resolution of 400 dpi. However, the WinPrinter cannot print without special driver software.

The WinPrinter includes a DOS-based TSR program with drivers that interpret HP's Printer Control Language (PCL). However, the most important drivers operate only under Windows. I tested the Windows drivers under Windows 3.0. (By the time you read this, LaserMaster expects to be shipping Windows 3.1 drivers.) The Windows drivers include a PostScript interpreter and a Windows Graphics Device Interface (GDI) driver (which the manual calls the "direct driver"). The PostScript interpreter is based on Microsoft's TrueImage, which includes support for both Adobe Type 1 and TrueType fonts.

The GDI driver receives print files directly from Windows applications. Because no intermediate interpretation steps are required (as they are with PCL and PostScript drivers), the GDI driver is the fastest of the three. However, it has some disadvantages. It does not use TurboRes to improve the effective resolution of fonts, and it does not relinquish control to other Windows applications during printing.

By contrast, the PCL and PostScript drivers run through a spooler. In fact, the spooler and interpreters run as 386 virtual machines using preemptive multitasking (Windows programs use cooperative multitasking). The preemptive multitasking lets other applications run while the WinPrinter is processing. Although this method slows down the printing process, you can continue to run other Windows programs (or spool additional print jobs) while you wait. It also limits the WinPrinter's operation to the Windows enhanced mode.

Speed Tests

So, how well does it all work? I tested the WinPrinter with a Northgate Elegance SP 486DX/33 with 8 MB of RAM. I

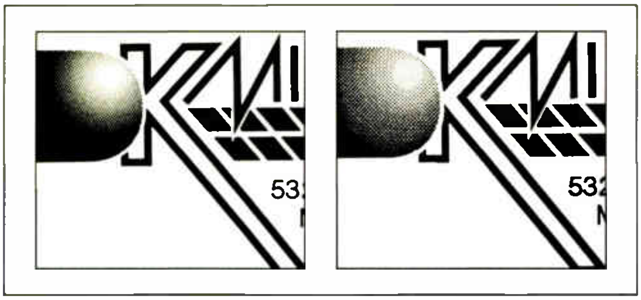

Figure 1: *The 400-dpi WinPrinter produces noticeably smoother gray scales and crisper line edges (left) than do 300-dpi printers like the Hewlett-Packard LaserJet (right).*

Figure 2: *A WinPrinter driver lets you print PostScript fonts and line drawings at 800 dpi (top), which improves sharpness even more compared to typical 300-dpi printers (bottom).*

created a 12-MB permanent swap file (the manual recommends at least an 8-MB swap file). PostScript pages that contained only text printed at a rate of about 3 ppm (after a delay of 27 seconds before the first page printed), which is a respectable performance for a 4-ppm printer running a PostScript interpreter.

After the WinPrinter's first few print runs, I noticed that the fonts and lines it produced were not as smooth as I had expected. I also discovered that the printer defaults to 400-dpi printing (with no TurboRes enhancement). Increasing the resolution to 800 dpi decreased the printing speed a bit, but the improved resolution was often worth the resulting performance degradation (usually only a few seconds per page). As with any printer, bit-mapped images add to the processing time significantly, so it was not unusual for the WinPrinter to take 2 to 3 minutes to print a single page when halftone images were included.

When halftone images dominate the page, the WinPrinter direct driver is sometimes the best choice. TurboRes technology doesn't improve the printing quality of halftone images—images always print at a resolution of 300 or 400 dpi. One of my CorelDraw test pages was nearly full of halftone images, with only a few characters and lines. From the time I started the print job, nearly 4 minutes elapsed before the page finished printing: CorelDraw used 1½ minutes to spool the output (blocking access to other Windows applications). With the direct driver, the image finished printing in just over 1 minute—less than the spooling time for the PostScript driver.

You might expect a significant performance degradation in your Windows applications while the spooler is at work. However, the default settings give low background-processing priority to the WinPrinter. In most cases, I saw no appreciable difference in application performance, whether the printer was busy with a large job or sitting idle. Graphically intensive operations, such as CorelDraw's preview mode, did not exhibit intermittent slowdowns. (In fact, the only applications that a print run seemed to affect were the Windows games Reversi and Solitaire. Even then, the overall performance remained good; for example, when Solitaire's cards would bounce across the screen, they would slow down for only 2 to 3 seconds just before each page would print.)

When several applications are running at once, at least one of them has to print more slowly. With the WinPrinter, the printing time for several concurrent applications increases. But, even so, this increase is not always significant. When I would intentionally keep the system busy (i.e., by constantly forcing screen redraws or intensifying mouse and keyboard activity), print jobs that formerly took 4 minutes would take about 4½ minutes. Of course, the overhead might be more significant on a slower 386 system. And since the drivers make use of a 387, the floating-point processing abilities of my 486 gave the system a performance boost.

The only problems I had with the WinPrinter were during Windows initialization. When Windows first starts, the printer initializes TrueImage processing in a DOS box. About three times out of nearly a hundred start-ups, the printer violated system integrity, and I had to exit Windows and reenter. (The WinPrinter never crashed the system or caused any problems if I did not reboot.) LaserMaster's technical-support staff suggested that there may have been a conflict with my Quarterdeck QEMM expanded-memory driver, but the problem did not occur often enough for me to reproduce it. In any event, it seemed minor, considering the many problems I've had configuring Windows for other hardware and software.

BYTE ACTION SUMMARY

WHAT THE WINPRINTER 800 IS
A PostScript printer for Windows that uses a host computer's 386 or 486 processor. Resolution-enhancement technology boosts PostScript fonts and line drawings to an effective resolution of 800 dots per inch.

LIKES
Fast processing speed in some applications and near-typeset-quality output.

DISLIKES
Occasional Windows initialization problems during start-up.

RECOMMENDATION
The printer is an economical solution for those who need Windows-based desktop publishing features.

PRICE
$2195

FOR MORE INFORMATION
LaserMaster Corp.
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fax: (612) 944-0522

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The user interface to the WinPrinter is well designed. You can switch among PostScript, PCL, and direct drivers through the standard Windows print configuration utilities (or the equivalent functions in a Windows application). Within each DOS box, you can address the PCL and PostScript drivers as different LPT ports, so even your DOS applications gain access to the WinPrinter. You can switch PostScript resolutions between 400 and 800 dpi on the fly for better performance or improved image quality.

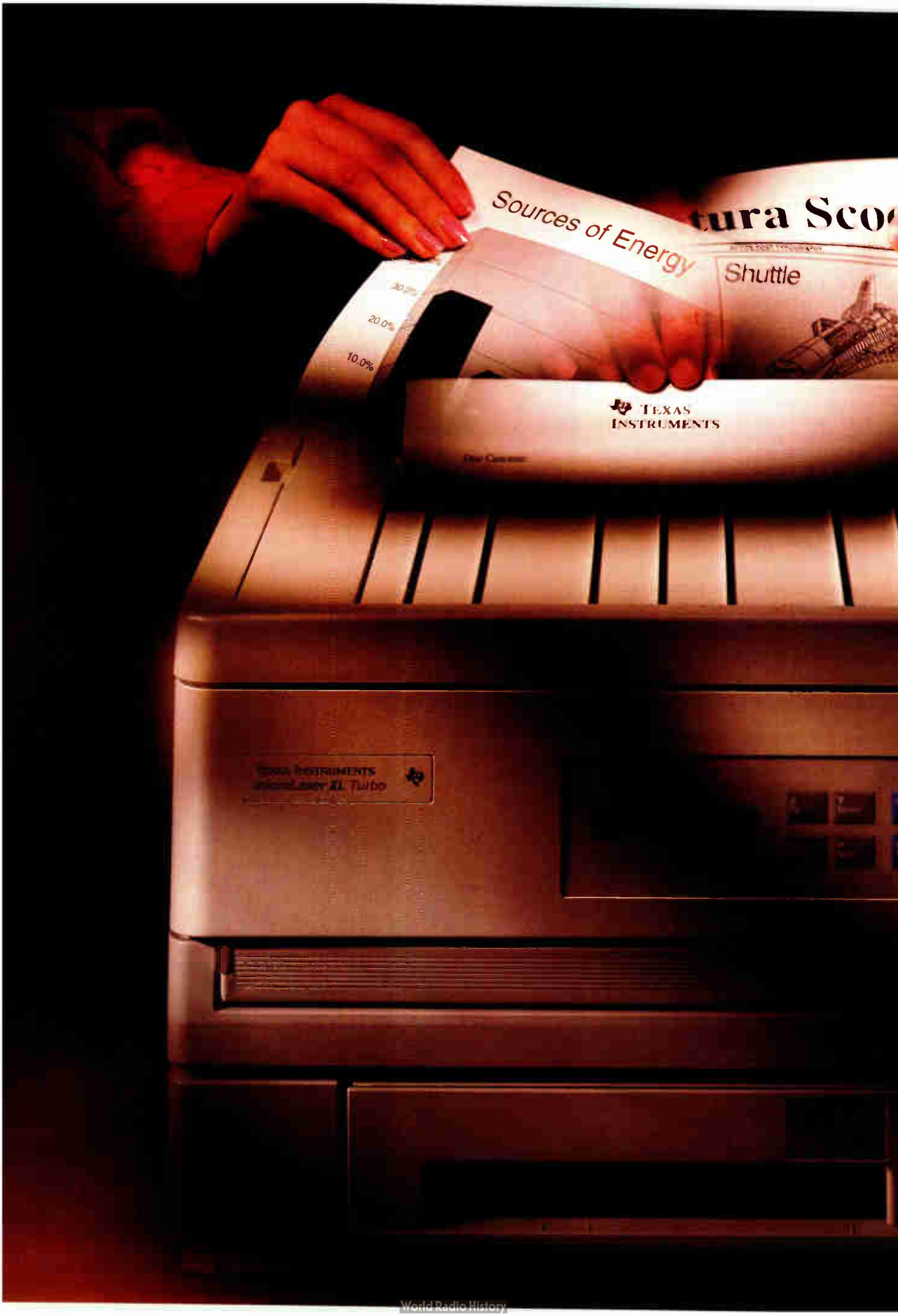
Overall, the documentation was helpful. There were a few minor errors, and I would have preferred more detail about the WIN.INI, SYSTEM.INI, and WINPRINT.INI files. Within the Windows environment, LaserMaster has attended to the details that make using the WinPrinter a pleasure. When a job is printing, the pages of an icon turn to indicate activity (you can disable this feature). You can open a window that describes the current activity on the printer. LaserMaster provides a utility that monitors system performance (although, in some cases, the performance monitor can itself slow down the system considerably).

A Desktop Publishing Solution

If you print most of your PostScript files through Windows, or use Windows for most of your applications, the WinPrinter may be worth consideration. It ranks high among the lower-priced printers with PostScript abilities while giving you TurboRes features that provide near-typeset-quality fonts and lines.

While its Windows orientation may be too limiting for some users, the WinPrinter has some design advantages over other printers. Because the features are programmed in on a 386, the driver software can be upgraded (or new features added) easily. As you move to faster systems, the performance of the printer improves. With system fonts that reside on the hard drive, you need not download or manage fonts. And you have several printing options to select the best performance and print-quality features for each print job. The WinPrinter is an economic solution for anyone who needs desktop publishing features in a reasonably efficient printer. ■

Bradley Dyck Kliewer is the principal of DK Micro, a PC and AS/400 consulting firm in Minneapolis, Minnesota. He is the author of EGA/VGA: A Programmer's Reference Guide, *2d ed. (McGraw-Hill, 1990), and he can be reached on BIX as "bkliewer."*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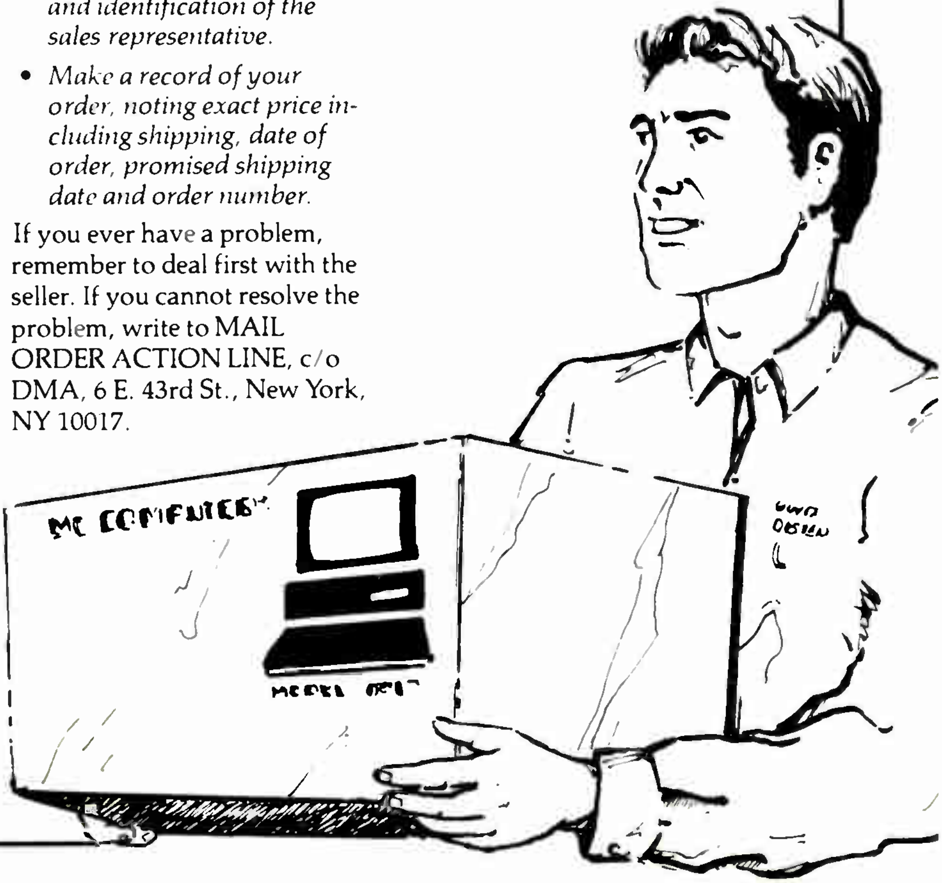


APPLICATION

Presentation Graphics That Deserve an Extra Bow

TOM YAGER

Curtain Call for Windows combines the best features of presentation graphics packages at a price that's hard to beat: $200. Even at this price, Windows users get special text- and graphics-enhancing features, such as three-dimensional extrusions and sophisticated drawing tools. When coupled with its capable script editor, Curtain Call lets you produce high-quality computer-controlled presentations with digital sound and MIDI music.

The program is not without flaws. Its interface is awkward, and I was disappointed that its audio didn't support the MPC standard. But I was impressed with Curtain Call's presentations and how quickly I could produce them.

Curtain Call's interface shows what it is: a cross between a paint package and a character generator.

A Shade Better

I tested the program on a Tandy 4033LX Multimedia PC with 8 MB of memory, although the product will run on any 386 or higher PC with Windows 3.0, a hard drive, and at least 2 MB of RAM.

The software makes excellent use of the PC's limited range of colors. Most PCs now come with 256-color VGA cards. But if you try to create a graduated background in a PC graphics package, you quickly run out of colors. To circumnavigate this shortcoming, Curtain Call ships with a set of custom color palettes. These palettes contain several colors in various shades and are arranged for effective color blends, including 3-D shading. This is a boon for those of us who aren't artists: It's like a musical instrument that doesn't let you play notes out of key. If you're just dying to mix orange and purple, however, you can modify the existing palettes any way you like.

In addition to color palettes, Curtain Call provides a set of *styles*, which are attributes applied to text and graphics. These styles are grouped into libraries called *schemes*, and each scheme has its own palette. The "metals" scheme, for example, has a palette loaded with shades of gold and silver and styles that use them to simulate the effects of light on shiny metal surfaces. Rendering attributes, like 3-D extrusion and shadowing, are combined with shading to produce rich-looking text and graphics.

To help you maintain a consistent look in your presentation, Curtain Call keeps track of four separate style selections: text, clips (imported graphics), and shapes produced within Curtain Call, and borders. For each of these, you can select any style in the currently active library; there are no distinctions between types (text, clip, shape) of styles.

Styles, and the effects they include, can be applied to text, shapes, and imported graphics. For example, I used Adobe Type Manager to add scalable fonts to Windows and used Curtain Call to render a sentence in simulated 3-D.

Curtain Call comes with Voyetra drivers for many popular audio boards and doesn't require the Windows Multimedia Extensions. However, this proved to be a problem, since the 4033LX Multimedia PC runs the Windows Multimedia Extensions that are part of the MPC specification. The extensions include their own set of sound drivers (loaded under Windows) that run afoul of those included with Curtain Call. To add sound to a Curtain Call presentation, I had to erase the audio driver references in my SYSTEM.INI file. Hopefully, a future release will include MPC support.

Special Effects

Curtain Call's interface is a little awkward, but it took only seconds to go from

BYTE ACTION SUMMARY

WHAT CURTAIN CALL IS
A Windows presentation graphics tool that incorporates a variety of dazzling graphical effects.

LIKES
Makes excellent use of a PC's limited range of colors; fast rendering of 3-D text and objects.

DISLIKES
Objects cannot be easily modified once drawn; no MPC support.

RECOMMENDATIONS
Probably the best value among Windows presentation graphics tools, but you might want to use something else to sequence and show your presentation.

PRICE
$199.95

FOR MORE INFORMATION
Brown-Wagh Publishing
130-D Knowles Dr.
Los Gatos, CA 95030
(408) 378-3838
fax: (408) 378-3577

Circle 1229 on Inquiry Card.

my sentence to a set of letters that had depth and were shaded as though the light were striking them from the upper left. Similarly, I was able to import a BYTE logo and have it extruded two ways: one in which the entire graphic (the rectangle surrounding the logo) was extruded to look like a plaque, and one in which the letters of the logo were traced and extruded individually. Both looked marvelous.

Curtain Call incorporates an effective, but not spectacular, paint package that is driven by a familiar tool palette. The work surface is presented in a scrolling window, and the entire interface sizes itself to the screen you're working on. The work area is always the size of the current screen, which can be a hassle if you're developing on one system and presenting on another. Curtain Call will scale your work to any size screen, but not on the fly; you have to load and save all your screens to the new size before you can present them.

This is because Curtain Call doesn't maintain text and graphics as individual, scalable objects. Each is distinct and changeable after you create it, but as soon as you "tack them down," they lose most of their properties. You can, at any time, lock the work area's current contents. This becomes the background, and you can work in the foreground without affecting the graphics you created before the lock. This two-layer system can be limiting; I'm used to having unlimited layers available and moving and stacking objects independently. Curtain Call will not allow that, although you can produce similar results with careful planning.

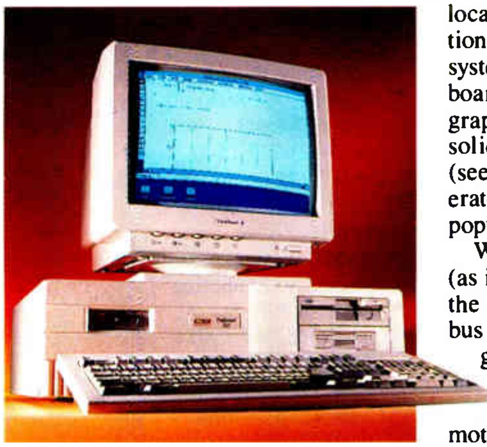
Text, borders, and shapes are created through pull-down menus. Once created, they become part of the image the moment you place them. Text can't be corrected or cleanly scaled, attributes can't be changed, and moving something you have created becomes difficult: You have to lasso it and move it around as a bit map, possibly dragging pieces of nearby graphics, or the background, if you're not careful, around with it.

Applause, Applause

Curtain Call's built-in presentation sequencer is simple to use, but its audio is not MPC-compatible. It uses a stripped-down version of the now-common timeline interface, such as StudioMaster Pro (see "Edit Video at Your Desk" on page 260). There is no flow control, but you can cue the next slide with the mouse, a key press, or a timed delay. Since Curtain Call saves each screen to a separate Windows-standard graphics file, you can use the tool of your choice if you require more control over your presentation. Asymetrix ToolBook worked well for me in sequencing a set of Curtain Call slides. Any number of Windows tools can be applied similarly.

Because it's so difficult to change your drawing once you have created it, the watchphrase for Curtain Call is "plan ahead." Even so, I recommend the program for the impressive results it produces. I'm paid to find fault, and I had no trouble finding things I wasn't completely happy with in Curtain Call. But you should know that I use this package for my own presentations because I've found nothing else that produces such excellent results with so small an investment of time, money, and effort. ■

Tom Yager is the director of BYTE's Multimedia Lab. He can be reached on BIX as "tyager" and on Internet at "tyager@bytepb.byte.com."



Local Bus Meets Windows Accelerator

Two techniques for speeding up slow graphics response have recently found favor with PC system manufacturers: local-bus video, which places video memory on the CPU bus, and hardware graphics accelerators, which can drastically improve primitive drawing operations where driver support is provided. We've looked at each of these techniques singly with a roundup of Windows accelerators ("Tweaking Windows: New Adapters Boost Speed and Clarity," January BYTE) and a review of NEC's local-bus entry, the PowerMate 386/33i ("Local Bus Fuels PowerMate's Graphics Response," April BYTE).

CSS Laboratories' Preferred 333GA takes a novel approach in combining local-bus video with hardware acceleration. CSS's MaxGraphics/32 video subsystem is a VGA-compatible accelerator board built around S3's popular 86C911 graphics chip. The 86C911 provides a solid boost in Windows performance (see the table); CSS also provides accelerator drivers for AutoCAD and other popular CAD packages.

Where driver support isn't available (as in many DOS graphics applications), the Preferred 333GA relies on its local-bus video connection to provide faster graphics. The MaxGraphics/32 card fits into an EISA-style 32-bit connector on the Preferred 333GA's motherboard. The first part of the connector provides access to the standard ISA bus for other cards, but the additional bits are used to provide a direct path between CPU and video memory. The result is excellent raw graphics speed even with applications that don't recognize the 86C911. The table shows that the Preferred 333GA wasn't quite as fast as the outstanding NEC PowerMate 386/33i on our DOS graphics benchmark, although it easily outran a Compaq Deskpro 386/33L equipped with a 16-bit VGA.

The 33-MHz 386DX-based Preferred 333GA includes MaxGraphics/32, 4 MB of RAM, a 120-MB IDE hard drive, two floppy drives, and a VGA monitor for $2895. It's well documented and solidly assembled. Given the 333GA's price and superior graphics performance, CSS's marriage of local-bus video and hardware acceleration should have a bright future.

BYTE BENCHMARK RESULTS

Although NEC's local-bus equipped PowerMate 386/33i edged out CSS Laboratories' Preferred 333GA on raw graphics throughput, as shown by its better score on BYTE's graphics test, the Preferred 333GA gets the nod on graphics-intensive Windows operations. Note that the Preferred 333GA was tested in 256-color mode, which is the only configuration that the S3 driver supports. The Compaq Deskpro 386/33L's scores (16-bit VGA) are provided for comparison.

	CSS Laboratories Preferred 333GA	NEC PowerMate 386/33i	Compaq Deskpro 386/33L
BYTE graphics test (iterations per second)	0.62	0.66	0.58
Windows operations (seconds)			
Display records (Superbase 4)	86.0	101.0	101.0
Paragraph moves (Ami Pro 2.0)	15.3	16.9	18.2
Text scroll (NotePad)	6.4	12.7	13.1

Hard Drives Form Quick Attachments

The range of portable peripherals that connect to PCs through the parallel port continues to grow. Recently, the BYTE Lab tested two hard drives from Simplicity Computing and BSE that attach in this way to avoid BIOS conflicts and having to add adapter cards.

With its Flashdrive 25, BSE targets owners of notebooks and laptops who need more storage. Simplicity pitches the Portable Drive to those who travel extensively and use a system at their destination. In either case, if travelers will be working at a desktop system in another office or using a client's PC for a presentation, the drives can carry the data and applications that would normally be stored at the home office. Alternatively, the drives can also store sensitive data that can be locked up at night. To address the latter, BSE's software provides password protection of data.

Installation Ease

We had no problems installing either drive or its associated software. The software automatically sets up the drives, and both programs provide utilities for formatting and partitioning. Neither drive can be set up as a boot drive.

Both units have a male parallel interface to attach a cable running from the computer and a female interface to continue the cable connection to a printer.

Simplicity uses a Conner 3½-inch IDE hard drive and includes a handy software program that can automatically add applications stored on the hard drive into the host system's path statement. In addition to the 80-MB model we tested, Simplicity also sells 40-, 120-, and 170-MB versions of the drive (prices are $499, $899, and $1299, respectively). An optional ($79) nickel-cadmium battery pack can provide power for more than 7 hours, Simplicity says.

Indicator lights on the front of the

drive show power and drive activity, in addition to the status of the battery pack. The drive is enclosed in a metal case that's sturdy enough to be jostled around inside a briefcase or in luggage. The drive weighs about 2 pounds and measures 4⅞ inches wide by 8 inches long.

BSE's drive weighs 1½ pounds and measures only 5 by 5 inches. A built-in nickel-cadmium battery can power the unit for 5 hours, or you can use AC power. In addition to offering password security, the software works with controller-based data compression, which can squeeze files on the fly an average of 50 percent, according to BSE.

We tested a model with a 20-MB capacity; BSE also sells 40-, 60-, 85-, and 130-MB versions (prices are $599, $699, $799, and $999, respectively). For those who already own a 3½-inch drive, BSE will sell the housing for $199.

Performance Comparisons

We compared drive performance by copying 11 MB of text files from the internal drive of our 25-MHz 386 PC to each of the external drives. We also copied the files to a directory on the internal drive. The copies averaged 8.6 seconds when the internal drive was the destination, 15.8 seconds for Simplicity's Portable Drive, and 36 seconds for BSE's Flashdrive 25.

In practice, the slow performance of the external drives, even the BSE drive, wasn't enough to make us shy away from them if we needed the advantages of portable data and applications. Price was a bigger concern. A 40-MB drive can be purchased for about $300, while 80-MB drives cost about $400, which means that parallel-port convenience can almost double the dollar-per-megabyte cost.

If your travel schedule, storage requirements, or security concerns lead you to parallel-port hard drives, the Simplicity Portable Drive stands out between these two devices. Its performance was faster, and its housing appears better suited for life on the road. ■

—The BYTE Lab

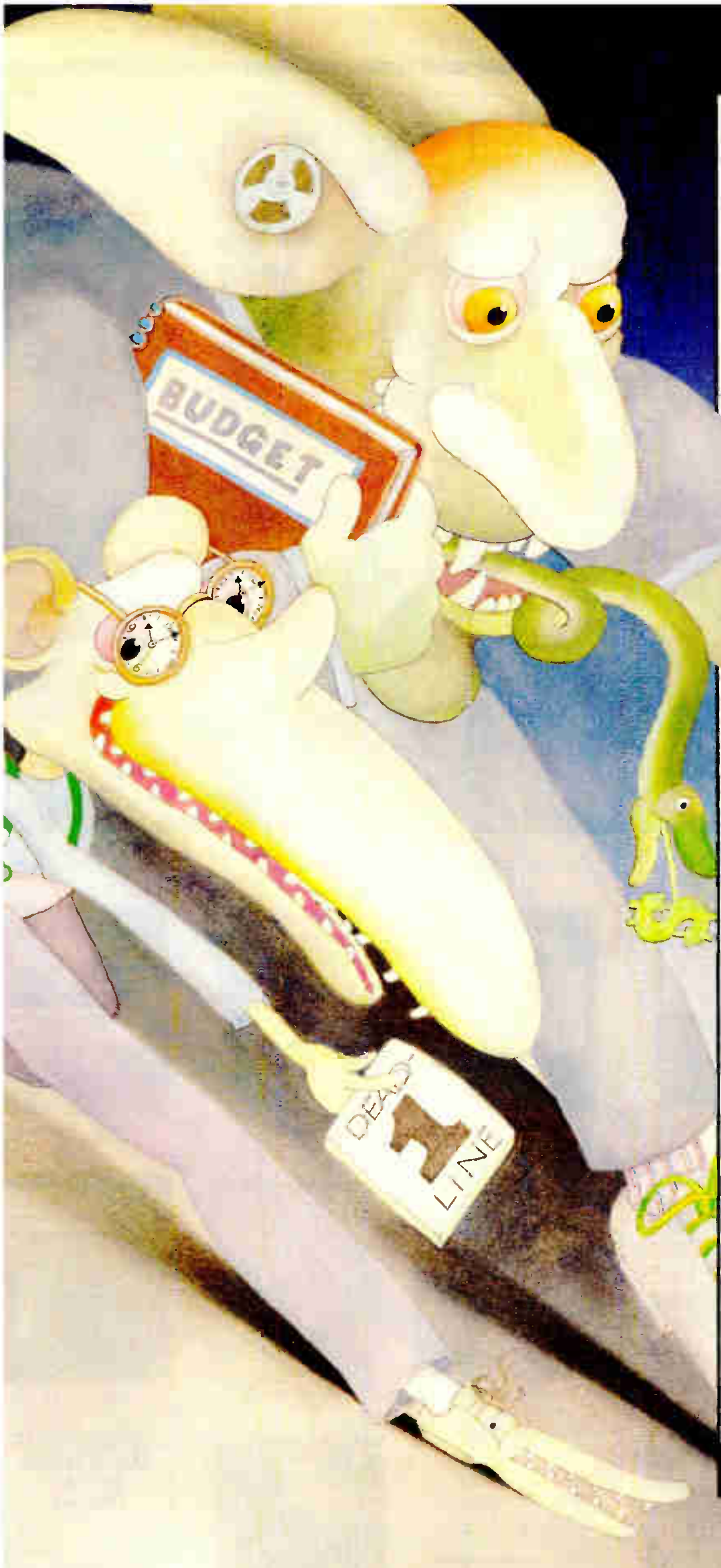
Reviewer's Notebook provides new information—including version updates, new test data, long-term usage reports, and reader feedback—on products and product categories.

ITEMS DISCUSSED

Flashdrive 25 .... $399
(20-MB version, as tested)
BSE Co.
2160 North Fourth St., Suite 210
Flagstaff, AZ 86004
(602) 527-8843
fax: (602) 527-1540
Circle 1232 on Inquiry Card.

Portable Drive $699
(80-MB version, as tested)
Simplicity Computing
126 West 23rd St.
New York, NY 10011
(212) 229-1625
fax: (212) 229-2938
Circle 1233 on Inquiry Card.

Preferred 333GA $2895
CSS Laboratories, Inc.
1641 McGaw Ave.
Irvine, CA 92714
(714) 852-8161
fax: (714) 852-0410
Circle 1231 on Inquiry Card.



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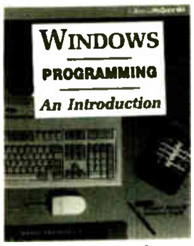

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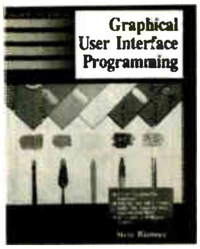

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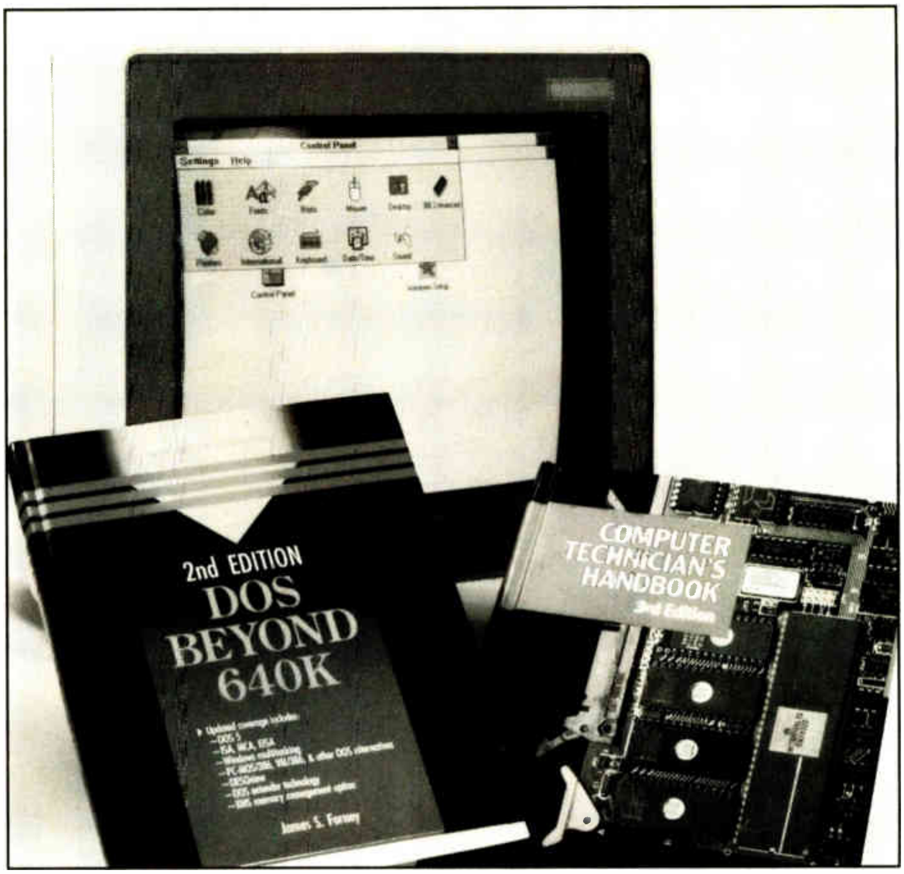

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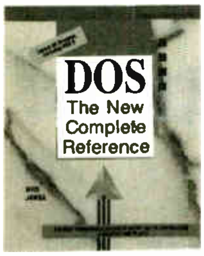

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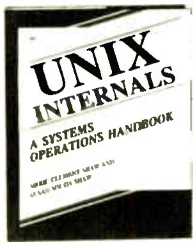

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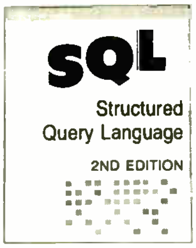

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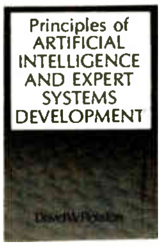

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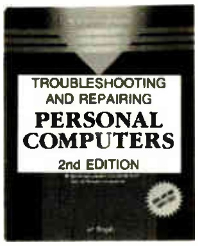

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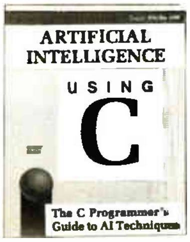

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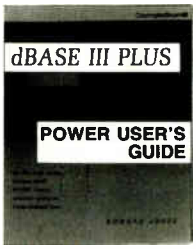

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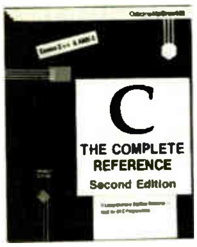

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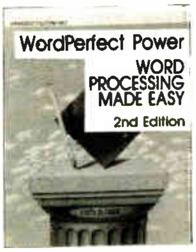

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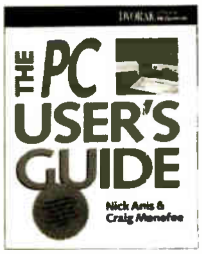

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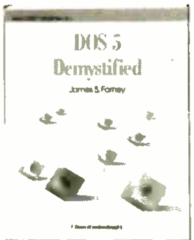

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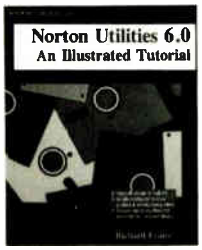

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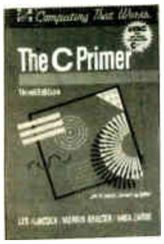

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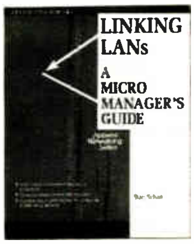

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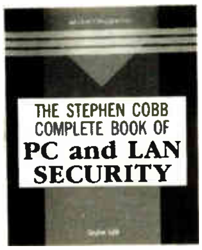

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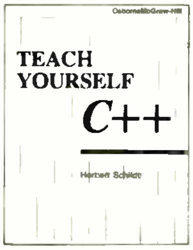

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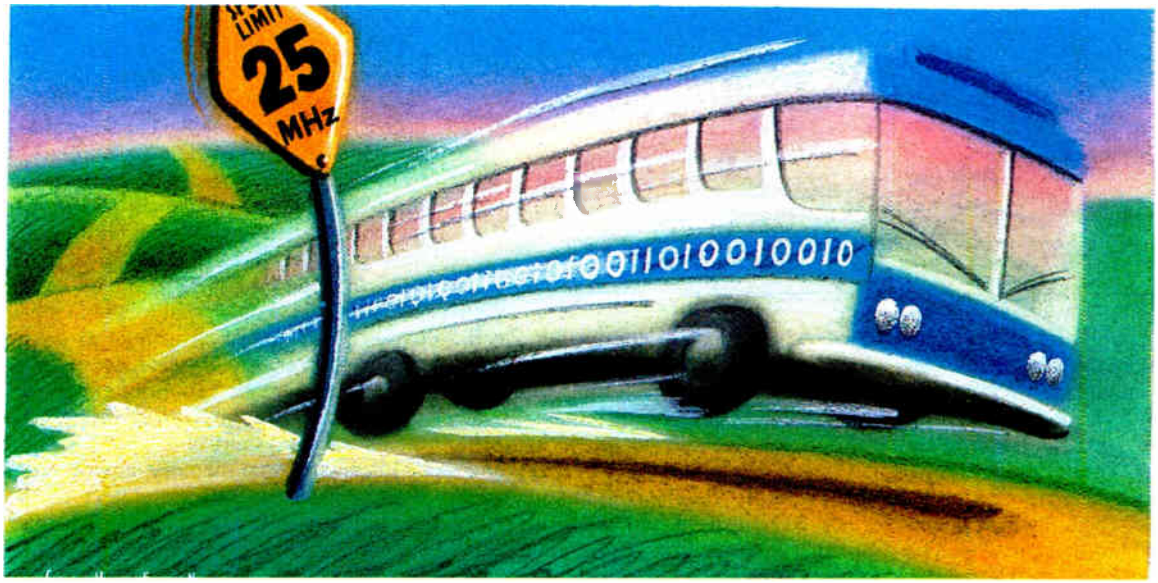
JIM LYLE

A RIDE ON THE SBUS



Simple yet capable, Sun's open I/O bus delivers the performance that workstations need

The SBus is an I/O bus developed by Sun Microsystems for use in its workstations and server products. It features high performance, simple transfer protocols, and an open specification that has enabled more than 100 vendors to develop a wide range of SBus products. Sun published the specification in late 1989 and has since encouraged its use by third parties.

SBus devices available today include the traditional I/O devices, such as frame buffers (i.e., video cards), serial line multiplexers, and LAN interfaces (e.g., Ethernet, Fiber Distributed Data Interface [FDDI], and ISDN), as well as more specialized applications such as digital signal processors (DSPs), 386- and 486-based DOS coprocessors, A/D and D/A converters, and graphics accelerators. More exotic SBus boards include text-to-speech converters, voice-recognition hardware, and even fuzzy-logic coprocessors. Most SBus-based workstations today are Sun Sparcstations, but makers of Sparcstation clones, such as Opus, Solbourne, and Mars Microsystems, use the SBus as well.

Design Requirements

High bandwidth is clearly an overriding requirement for a workstation. A bus interface for use in a high-performance workstation must be able to haul large amounts of data quickly. Workstation-class video cards can require 20 to 30 MBps; DSPs need between 5 and 20 MBps; and FDDI can consume 12 MBps. A machine designed to support even a few such features, in addition to the memory needs of a high-speed CPU, must be able to move tens, if not hundreds, of megabytes per second.

The SBus, capable of sustaining 80 MBps in 32-bit burst mode and 160 MBps in 64-bit burst mode, meets the needs of the workstation world. What accounts for this performance? The SBus's clock runs at rates of between 16.67 and 25 MHz. It operates synchronously and uses simple protocols that add little overhead to each data transfer.

Low latency, though a more subtle requirement than raw bandwidth, can mean just as much to workstation performance. *Latency* is the delay between the instant a device (e.g., the CPU) requests a transfer and the instant the transfer is completed. Suppose the processor needs some data, but the bus is tied up by a DMA disk controller that can move data on its own. The processor cannot proceed until the current transfer completes. Its performance will therefore suffer, no matter how fast it can transfer data once it does gain control of the bus. Low SBus latencies are possible because devices can get on and off the bus quickly. An entire transaction can complete in five clock cycles or less. Also, arbitration occurs in parallel, and data can be transferred in bursts. Both of these features reduce latency by further reducing

ILLUSTRATION: DAVID CHEN © 1992

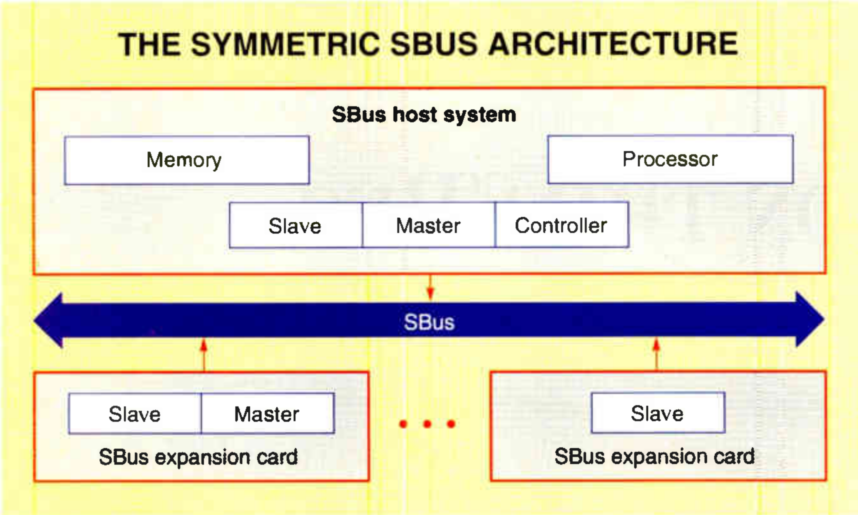


Figure 1: *Every SBus has one or more masters, one or more slaves, and one controller.*

each transaction's overhead.

The low latency of the SBus helps with another design requirement: low cost. Unlike the processor, some devices (e.g., serial or Ethernet devices) can't wait to get control of the bus. These devices therefore require additional memory so they can buffer the data. The longer the potential wait, the more buffer they need. The SBus reduces the need for such buffering, which makes SBus devices simpler and less expensive to design and build.

Another factor is the simplicity of the SBus's synchronous transfer protocols. All transitions occur at one clock edge and are sampled at the next. Synchronous logic is the easiest logic to design and the most reliable once it's built. It is relatively insensitive to glitches, and its timing requirements are straightforward and easy to understand. Also, synchronous logic is usually more efficient, because signals don't have to be resynchronized. All these factors help keep the bus interface as inexpensive as possible.

It's important to note that in simplifying the interface, the SBus designers chose to restrict the bus to just I/O operations. Machines that use the SBus typically rely on another bus—for example, the MBus or Futurebus+—to connect the processor to system memory. This arrangement means that the SBus must handle fewer kinds of transactions and doesn't need to concern itself with issues such as cache consistency. It also reduces the SBus's required bandwidth, since the two buses, working in parallel, can share the load.

Another of the SBus's primary goals is low power consumption. SBus devices can achieve high data rates using low drive currents; this enables application-specific ICs and other high-density ICs to drive the signals directly from their I/O pads. The bus's electrical characteristics are all CMOS, too, because that allows compatibility with the densest, fastest logic families available. Ideally, the bus interface could be built right into Ethernet, SCSI, or other adapters' primary components, eliminating extraneous signal buffers and state machines. Low power consumption helps make an SBus card suitable for battery-powered applications such as laptops, but it also helps on the desktop by reducing the size and cost of power supplies. It also simplifies cooling: Fans can be made smaller or eliminated altogether.

Finally, there's the issue of scalability: The bus should work in small laptop and desktop machines as well as high-end servers. If one board can support all these environments, it can be used by many different customers. Conversely, the customer who buys a laptop, desktop, or server will have a lot more add-on boards and products to choose from. Because SBus devices don't need much power and can require fewer interface components, they're well suited to low-end applications such as laptops. But these devices can deliver the performance needed in high-end applications as well.

Distinctive Features

The SBus is a *mezzanine* bus, which means that expansion cards attach to the motherboard in such a way that they remain parallel to it. Mechanically, the most noticeable aspect of an SBus card is that it is very small. Each single-width card is about 3.3 inches wide and 5.8 inches long. Although this is a small area, it's usually ample for most needs, because components can be mounted on both sides of the card and the bus is well suited to high-density circuitry. Double-width SBus cards, which are twice the width of standard-size cards, can be built if necessary, but they are discouraged because they occupy two slots.

Some SBus devices have data paths that are only 8 bits wide, while others are 16, 32, or even 64 bits wide. The simplest devices, called *slaves*, can only respond to operations, while more complex devices, called *masters*, can initiate transfers. Support for multiple masters boosts the efficiency of the bus, because the host CPU does not have to be involved in every transfer. This arrangement is usually referred to as DMA (direct memory access), but on the SBus it is referred to as DVMA (direct virtual memory access), because the master uses virtual addresses.

Virtual addressing might seem like the last thing you would want to add to a bus that is being simplified as much as possible. Just the opposite is true, however. Virtual memory greatly simplifies many software functions for both device drivers and the operating system.

Because virtual memory support is an integral part of the SBus architecture, the operating system and the bus-controller functions can handle the dirty work. Master and slave devices can be as simple as those built for environments that use purely physical addresses; they might even be simpler. For example, a DVMA master has no need for the scatter/gather functions that enable some DMA controllers to stitch together data scattered across fragments of physical memory. Virtual addressing also helps to eliminate the need for DIP switches and device-driver command-line parameters. The system assigns virtual addresses to SBus devices, so these devices need not concern themselves with absolute physical addresses.

Masters and Slaves

The basic architecture of an SBus-based machine is shown in figure 1. Every SBus has one or more masters, one or more slaves, and one controller. The masters initiate transfers after asking for and gaining control of the bus. The slaves respond to transfers, writing or reading data as requested by the masters. Each host usually has both master and slave interfaces. Expansion cards may be slave-only devices, or they may have both master and slave capabilities.

The controller is unique and is usually part of the host. It provides the SBus clock, does the virtual address translations, selects which master will perform the next transfer, and provides a time-out error if the slave does not respond within a preset time limit. The names and functions of the SBus's signals are listed in the table.

A high-density 96-pin expansion connector brings these signals from the motherboard to the expansion card. All signals but the seven IRQ* signals can be sampled synchronously. The interrupt signals are asynchronous and must be driven with open-collector (or open-drain) outputs so that devices can share them.

In general, the SBus maintains separate data and address paths. This simplifies the design of slave interfaces, which do not have to demultiplex and latch the address. In systems that demand very high I/O bandwidth, though, performance can matter more than simplicity. Here it may make sense to multiplex addresses and data. That's just what happens in the SBus's 64-bit extended transfer mode. The Read, Size, and PhysAddr signals multiplex with the Data signals to form a 64-bit data path.

The 64-bit extended transfer mode, which is described in revision B.0 of the SBus specification released in January 1991, is still somewhat exotic. One of the first devices to use the 64-bit transfer protocol will be Motorola's recently announced SBus Goldchip, a general-purpose DMA interface chip.

Shared Signals

Many SBus signals are shared; that is, different devices drive them at different times. Ownership can change between transfers, or even during a transfer. During read transfers, the Data lines provide a good example of ownership change. At the start of a transfer, the master drives the virtual address onto the Data lines, but by the end of the transfer, the slave is driving the transaction. When an ownership change occurs, it's critical to ensure that no more than one driver is ever enabled. Otherwise, a "bus fight" occurs. Driver overlaps such as these may cause improper logic levels, excessive power dissipation, and oscillation. The result may be erratic behavior or even damage to the drivers. This is especially true with CMOS technologies.

To prevent bus fights, one driver must be completely disabled before another can be enabled. To ensure this mutual exclusion, the SBus protocols are designed so that no more than one output will ever drive a signal during any clock cycle. In figure 2, driver A is disabled on one clock edge, and driver B is enabled on the next. Ack* and LateError* are control signals that are driven low when asserted. These signals are shared and are driven only at specific times during a transfer. At other times they are undriven, but they cannot be allowed to float. If they did so, they could float into an asserted state, which could interfere with a subsequent transfer. They also could hover at or near the receiver thresholds, which would increase power consumption and possibly cause oscillations or erratic behavior.

Pull-up resistors are a traditional solution to this kind of situation, and they work here if their value is high enough that a low-power chip output can overdrive them. If the resistor value is high, however, the time constant it forms with the signal's capacitance will be long. The slow rise time that results could be as long as several microseconds. This may be dozens of clock cycles, which ultimately is not much better than just letting the lines float.

Fortunately, there is an easy solution to this dilemma: active-drive. This principle requires that any output that actively asserts a signal must then actively deassert it. After that, even a high-value pull-up resistor can hold a signal in the deasserted state until the signal is driven again.

An SBus Transfer

The timing diagram in figure 3 illustrates a basic SBus transfer. All SBus transfers are divided into three major stages. The first is arbitration, during which SBus masters request and can be granted access to the bus. The second is translation, during which the SBus converts a virtual address into a physical address. Last is the transfer phase, during which the master and slave exchange data.

During the arbitration phase, an SBus master shows that it wants to do a transfer by asserting its BusRequest* signal. Each potential master has its own BusRequest* signal. This arrangement, called *radial* because signals fan in from multiple masters, means that the SBus controller knows immediately which master has made the request. If multiple masters are making requests, the controller must choose which master will be allowed to do its transfer next. The chosen master can proceed with its transfer when the controller asserts its BusGrant* signal. As with BusRequest*, there is one BusGrant* signal for each potential master. The dedicated, radial BusRequest* and BusGrant* signals allow arbitration to occur in parallel with the rest of the transaction's phases.

The translation phase begins right after the master samples BusGrant* and finds it asserted. The master must then drive a virtual address onto the Data lines, drive the transfer size it wishes to perform onto the Size lines, and drive the transfer direction onto the Read line. All these lines must be driven quickly enough to meet the setup

SBUS SIGNALS

All signals but the seven IRQ signals can be sampled synchronously. The interrupt signals are asynchronous and must be driven with open-collector (or open-drain) outputs. That means that SBus devices can share IRQs.*

Name	Abbreviation	Description	Driven by
PhysAddr(27:0)	PA(27:0)	Physical address	Controller
SlaveSelect*	Sel*	Slave select (one per slave)	Controller
Data(31:0)	D(31:0)	Data	Masters/slaves
Size(2:0)	Siz(2.0)	Transfer size	Masters
Read	Rd	Transfer direction	Masters
Clock	Clk	SBus clock	Controller
AddressStrobe*	AS*	Address strobe	Controller
Ack(2:0)*	Ack(2:0)*	Transfer acknowledgment	Slaves/controller
LateError*	LErr*	Late data error	Slaves
BusRequest*	BR*	Bus request (one per master)	Masters
BusGrant*	BG*	Bus grant (one per master)	Controller
Reset*	Reset*	Reset	Controller
IntReq(7:1)*	IRQ(7:1)*	Interrupt request (open drain)	Slaves
DataParity	DtaPar	Data parity (optional)	Masters/slaves
Ground (7 pins)	Gnd	Ground	Controller
+5 V (5 pins)	+5 V	Power (2 A per slot)	Controller
+12 V	+12 V	Power (30 mA per slot)	Controller
-12 V	-12 V	Power (30 mA per slot)	Controller

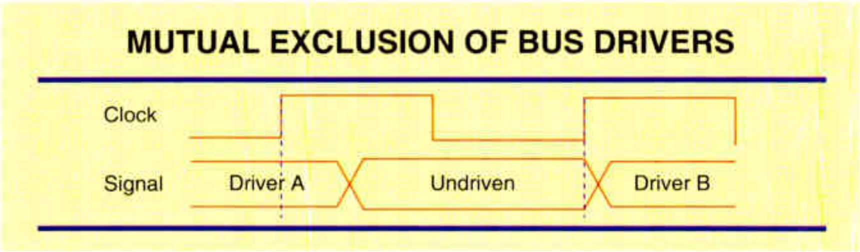


Figure 2: *Driver A is disabled on one clock edge, and driver B is enabled on the next. This ensures that no more than one output will drive a signal during any clock cycle.*

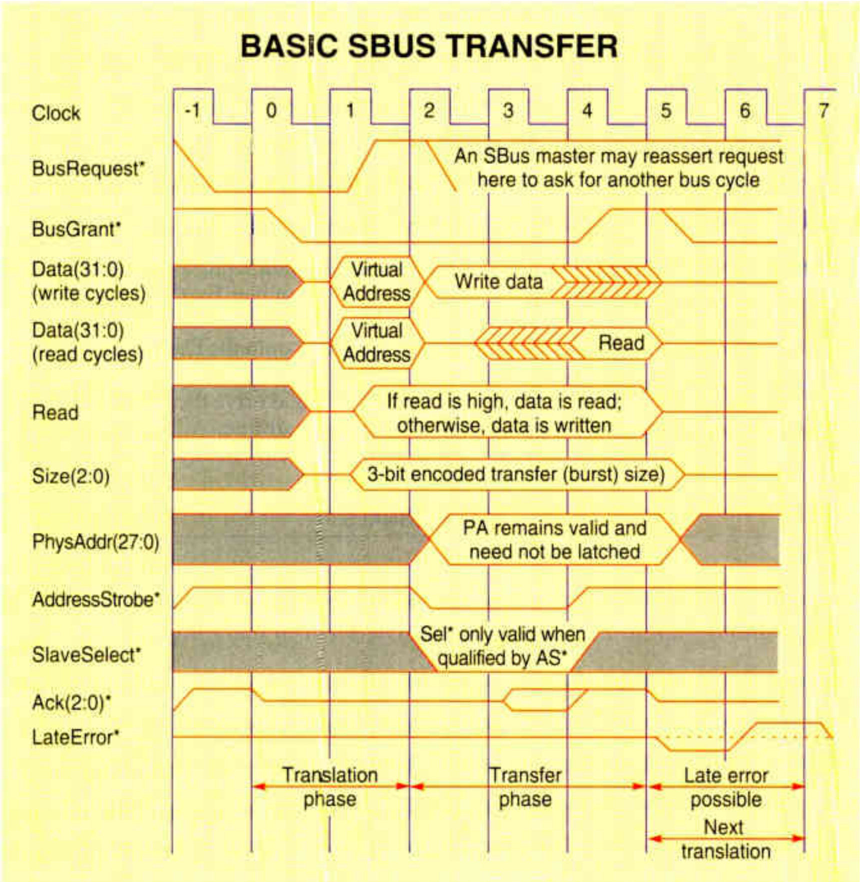


Figure 3: *During arbitration, SBus masters request and are granted access to the bus. The translation phase converts virtual addresses to physical addresses. Then, in the transfer phase, data moves between master and slave. Arbitration occurs in parallel with translation and transfer, between clocks -1 and 0, and again between 2 and 6.*

time for the next clock edge (clock 2 in figure 3). The bus holds the virtual address for exactly one clock cycle. After that, the master must either replace it with the data to be transferred (if a write is being performed) or tri-state the lines (if a read is being done). The Size and Read lines must be held stable throughout the transfer.

The SBus controller translates the virtual address into a physical address, which it drives onto the PhysAddr lines (only one clock cycle is required for the translation shown in figure 3, but more may be required). The controller also decodes the address and asserts one of the SlaveSelect* signals to the SBus slave, which is the target of this transfer. Like BusRequest* and BusGrant*, the SlaveSelect* signals are radial: There is one for each slave. Therefore, the slave knows immediately that it is expected to participate in the current transfer. Once the PhysAddr and SlaveSelect* signals have been driven, the controller also asserts AddressStrobe* to show the validity of this information.

The transfer phase is the part of an SBus transaction in which data moves to or from the slave. Either way, the slave is the lead performer in this part of the operation; therefore, this phase is sometimes called the slave cycle. If the current operation is a write, the master provides and holds the data on the Data lines until the slave is ready, signals an error, or asks the master to retry the operation (e.g., if the slave is busy). The slave does this by way of an encoding on the three Ack* lines.

The master must guarantee that the data remains valid until the clock edge at which the Ack* is sampled (clock 4 in figure 3). The herringbone pattern in figure 3 indicates that the master can continue to drive data for one clock cycle past that in which AddressStrobe* is deasserted. This arrangement is useful because it allows the master to use AddressStrobe* synchronously (as it should) in its data driver-enable function.

If the current operation is a read, the slave places valid data onto the Data lines after Ack* is sampled. This data must be held until the master samples it on the clock edge right after the clock edge at which Ack* was sampled and found asserted (in figure 3, the rising edge of clock 5). The slave may indicate an error on the transfer by asserting an error acknowledgment or by driving LateError*. If the latter is used, it will be sampled exactly two clock edges after that at which Ack* was sampled and found asserted (the rising edge of clock 6 in figure 3).

An SBus slave controls the data transfer rate by controlling the rate at which it issues data acknowledgments. The slave can issue data acknowledgments as soon as the protocol allows, or it can insert wait states if it needs extra time to complete the operation. If no slave responds within a set time-out period, then the controller must assert an error acknowledgment. This rule ensures a deterministic outcome. After the last acknowledgement is asserted in any transfer, the controller deasserts AddressStrobe* and the current BusGrant* and SlaveSelect* signals.

The SBus provides a dynamic bus-sizing mechanism that allows a master to communicate easily with slaves of various widths. Bus sizing occurs as the result of an implicit negotiation that takes place between the master and the slave during a transfer. The master selects the size of the transfer it wants to do by placing a code on the Size lines. The slave responds with its port size, encoded on the Ack* signals. If the two don't agree, then only part of the requested data can be transferred. The master must then drive follow-on cycles to transfer the remainder. For example, suppose a master initiates a 32-bit transfer to an 8-bit slave. The slave will provide (or store) the first byte of data along with an acknowledgment that signals its width. A master that supports bus-sizing must then perform three additional transfers to move the remaining 3 bytes.

The SBus also allows burst transfers. These are more efficient than nonburst operations, because the overhead burden of each transfer is shared by multiple words of data instead of single words, half-words, or bytes. The sequence of events in a burst transfer is similar to that of nonburst operations, except that multiple words move during the transfer and bus sizing does not occur (all burst operations are 32-bit transfers). Arbitration and virtual address translation work the same way, and the slave still acknowledges each word that's transferred. The maximum burst size is 16 words for 32-bit transfers, or 32 words for 64-bit transfers. With burst transfers, the SBus can sustain rates of 80 MBps at the normal 32-bit widths. Rates of 160 MBps are sustainable using 64-bit widths.

The Future of SBus

The SBus is a simple, high-performance, low-cost, low-power expansion interface that's well suited to the I/O needs of RISC workstations. In less than three years it has garnered wide support, and it continues to pick up steam. A working group within the IEEE called P1496 is developing the next revision of the bus's specification. One feature under consideration is the ability for a master to support multiple devices. This arrangement would facilitate multiprocessing; for example, an SBus expansion card might provide several DSPs running simultaneously.

Recently announced SBus interface chips, such as Motorola's Goldchip, will make it even easier to build SBus cards. New machine architectures under development will multiply available slots and bandwidth by using multiple SBus interfaces. The SBus won't be limited to SPARC-based machines for long, either. Don't be surprised to see the SBus turn up in VME, Futurebus+, and even PC environments. ■

Jim Lyle is a hardware design engineer in Sun Microsystems' SBus Technical Support Group and also works as a consultant through Troubador Technologies (Santa Clara, CA). You can reach him on BIX c/o "editors."

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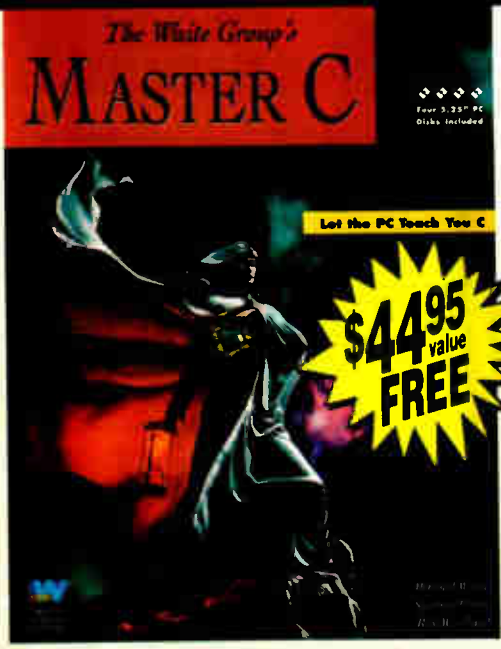

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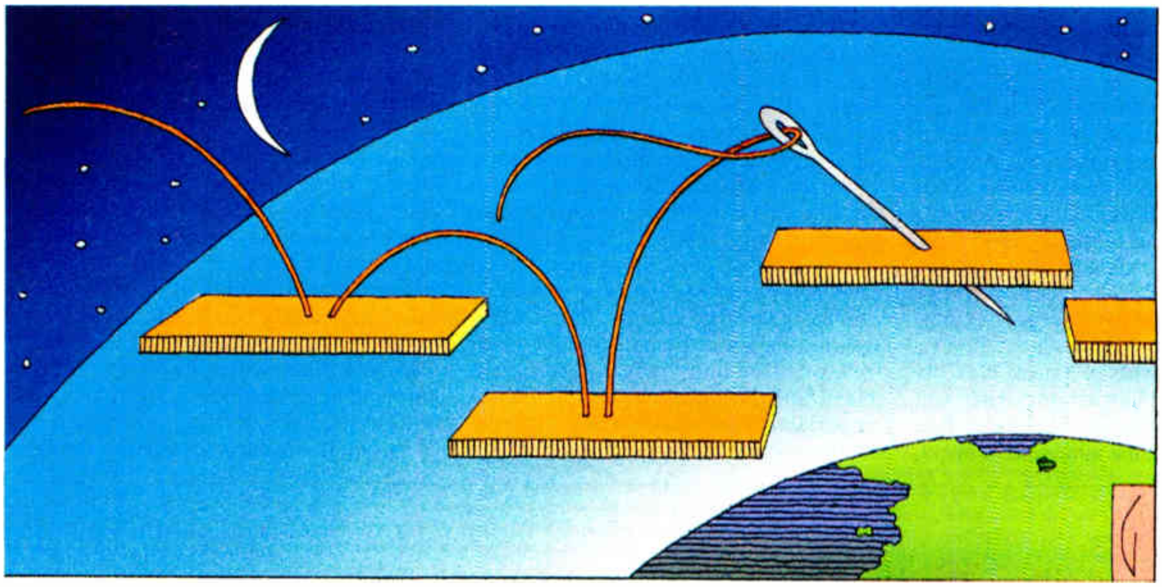
IT'S A MULTITHREADED WORLD, PART 1



Multithreaded operating systems are changing the world. Are your applications ready?

No matter what you may think of OS/2's future, its place in history is assured as the first operating system to introduce multithreading to personal computers. This distinction is lost on many developers, who may not fully understand what threads are, where they're needed, or how to use them. Yet multithreading operating systems, such as Sun Microsystems' Solaris and Microsoft's Windows NT (New Technology), and the proposed Posix multithreading standards for Unix are rapidly changing the world. Applications must start taking advantage of this powerful feature to stay competitive.

Understanding Threads

What are threads, and how do you use them? To unravel the mystery, you must first understand the basic operating-system concepts and terminology.

A *process* is an executing program that owns resources. These resources include open files, shared memory, message queues, semaphores, pipe handles, and even static (global) memory. Multitasking is the ability to schedule multiple tasks for execution. A single-processor machine uses a sequential multitasking operating system, and only one task actually executes at a time. In contrast, a multiprocessor machine uses a parallel multitasking operating system, and multiple tasks can execute concurrently.

The operating system contains a scheduler that controls what is executing and what has yet to execute. In OS/2 parlance, the smallest unit of execution that you can schedule to run is a *thread*, which is simply a path of execution through a process. When a program is ready to execute, the operating system creates a thread to represent the process and schedules that thread for execution. This becomes *thread 1*, or the *primary* thread. In a single-threaded application, the thread begins execution at the function `main()` and continues until the process terminates. This is a sequential algorithmic application.

The multitasking aspect of the operating system permits a thread to start one or more other threads. This is similar in concept to a multitasking operating system in which one process can execute another process. And since a thread is a path of execution through a process, one or more threads can be scheduled for execution through the same process.

To clarify this, consider an application containing the functions `main()` and `foo()`. On a multithreaded operating system, it is possible to start one thread (the primary thread) that begins execution at `main()`. This thread may then invoke a second thread to begin execution starting at `foo()`. Both threads are scheduled for execution at the same time. Remember, though, that the operating system can physically evaluate only one thread's instruction code at a time. Therefore, a process consists of one or more threads that share the process's resources.

continued

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The problem is how to separate the application into discrete tasks that can become threads. Some programming languages treat a process as a series of tasks. The programmer designs the application so that the tasks can theoretically execute concurrently. Ada, for example, treats a process as a series of Ada tasks. Although Ada provides a structured approach to multitasking, the application must still provide effective synchronization between tasks. In essence, the Ada application must partition the application design to take advantage of multitasking.

A process can have up to 512 threads associated with it under OS/2 1.3. The primary thread can create other threads for execution within the same process space. OS/2 assigns each a thread identifier (TID) and attaches the thread to the scheduler's list. A TID is local to the process; thus, every process has a thread whose TID is 1. Each process also has a process identifier (PID) that's unique for all processes running on the system.

Each thread consists of a stack, the CPU state, a priority, an instruction pointer, and an entry in the system's scheduler list. Since threads share the same near segment, you must carefully implement memory management to ensure that one thread does not unintentionally trash the heap. A thread can exist in one of three states: It may be blocked while waiting on some event, it may be scheduled to execute, or it may be executing. A blocked thread consumes almost no CPU time. The threads within a given process may have different priorities, and one thread may affect the priority of another. The `DosSetPrty()` function alters the thread priority.

The scheduler can preempt the currently executing thread when it receives a hardware interrupt or when some other event occurs; it saves the currently executing thread's context and invokes the appropriate driver to service the interrupt. Some system calls will also cause a transition to kernel mode. And the operating system preempts a thread when it executes for a certain number of clock cycles. This is called a *preemptive scheduling system*.

When it preempts a thread, the scheduler searches its list of threads that are ready for execution and gives control to the thread with the highest priority. If the preempted thread has not used all of its available time slice, it receives preference. The scheduler will also temporarily boost the priority of a thread that has become starved for CPU time. This technique is referred to as *time slicing*. The process of switching from one thread to the next is known as *context switching*.

The CONFIG.SYS file contains several directives for effecting thread execution. The `THREADS=n` directive specifies that the maximum number of available threads is to be *n*, where *n* is greater than 16. The `TIMESLICE` directive defines how many CPU milliseconds a thread can consume before preemption. The format is `TIMESLICE=x[,y]`, where *x* is the minimum amount of time and *y* is the maximum amount. When a thread uses up its entire time slice, the scheduler increments the next time slice by 1, up to the maximum value set by *y*. This helps to limit context switching when several threads are running at the same priority. The *y* value is used for round-robin scheduling among threads of equal priority.

The `MAXWAIT` directive in the CONFIG.SYS file specifies the number of seconds a thread must wait before having its priority boosted. Raising priority levels is essential when higher-priority threads run continuously.

The PRIORITY=DYNAMIC|ABSOLUTE directive specifies whether or not threads can be adjusted within their class based on their execution history. An ABSOLUTE priority means that threads cannot be adjusted. In this case, the MAXWAIT directive has no effect.

The Role of Semaphores

Protecting an application's resources is a difficult programming challenge when you're using multiple threads within a single application. You must be able to synchronize access between threads to critical static data. In the simple case of two threads executing within the same process space, how can you synchronize access to prevent thread 1 from deleting the data while thread 2 is using it?

Consider what happens when two threads enter the same function that contains logic to test a file pointer. If the value is NULL, the threads open file foo for a write. Thread 1 might test the file pointer, see that it is NULL, and then time out before it issues fopen(). The scheduler may then select thread 2 for execution. Thread 2 enters the same function, finds the file pointer still set to NULL, opens the file for writing, and writes data to the file. When thread 2 times out, the scheduler may opt to run thread 1, which was just about to open file foo for writing. A collision for the resource occurs.

When two threads contend for the same resource, one can issue a DosSuspendThread function call to halt the other. It then restarts the other thread by issuing a DosResumeThread() function call.

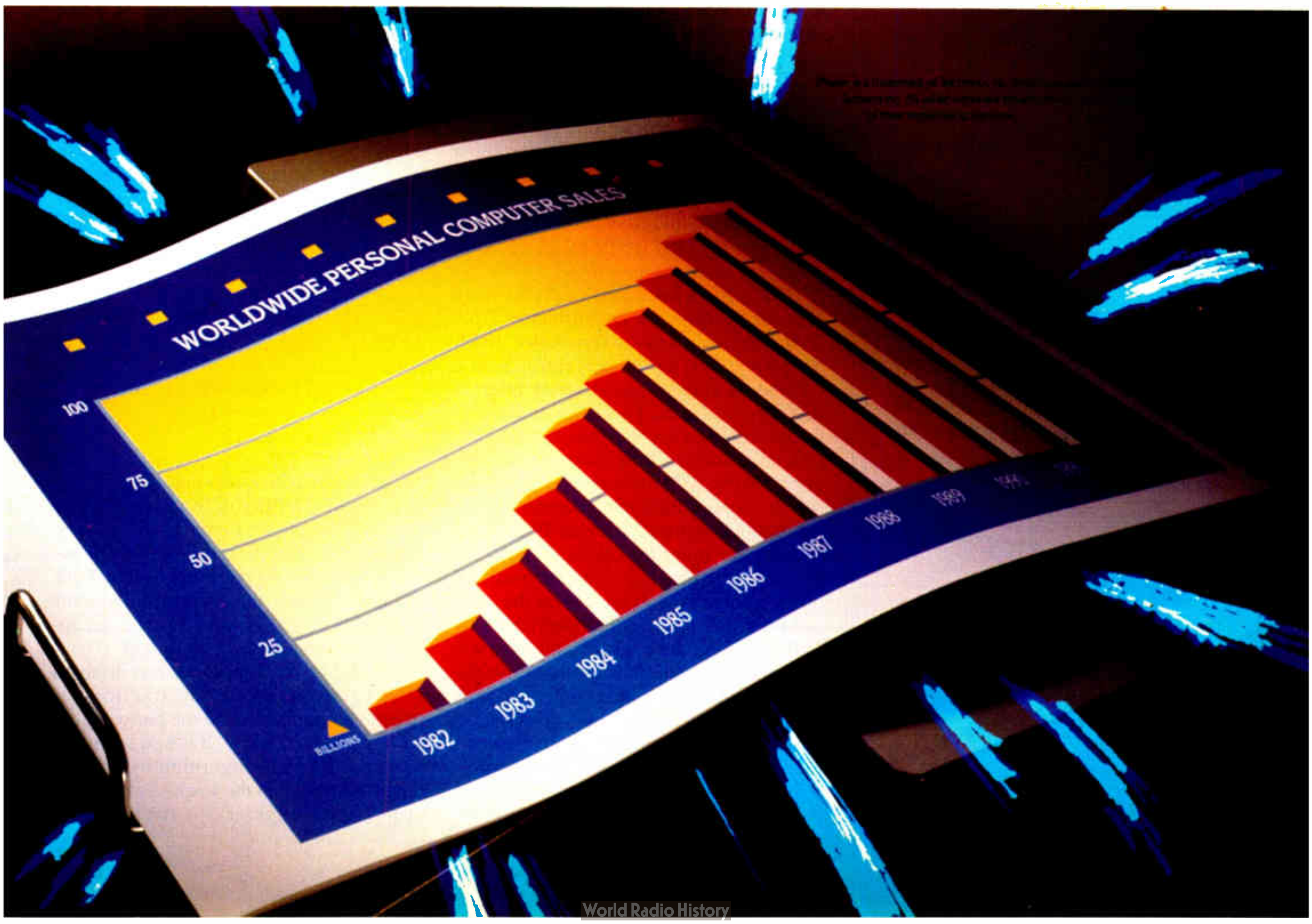
A suspended thread cannot restart itself. A thread may, however, put itself to sleep for a predetermined period of time. When the period expires, the thread can be rescheduled for execution.

Specifying a zero time period forces the scheduler to preempt the thread and reschedule it. It's possible for thread 1 to force thread 2 to suspend while thread 1 completes using the resource. This would work, provided that thread 1 knows the TID for each thread it must suspend. But it's an inefficient implementation for applications with a more dynamic multithreading architecture.

The DosEnterCritSec() and DosExitCritSec() function calls represent another approach to synchronizing access to global data structures. When a thread enters a critical section, these calls ensure that it will not be preempted. This approach has several disadvantages. If the thread hangs, the whole system hangs. Also, a thread that performs I/O during a critical section makes inefficient use of the CPU. Finally, threads with a higher priority cannot execute while the thread is in a critical section. Avoid the use of critical sections when possible.

You can also use semaphores to control access to critical resources. When a thread wishes to use a critical resource, it must first gain ownership of the resource's semaphore. After using the resource, the thread frees the semaphore so that other threads can use it. If, for example, thread 1 owns the semaphore associated with a critical resource, then thread 2 must wait until thread 1 frees the semaphore before it can access the resource. When more than one thread wishes to use the resource, contention occurs.

Semaphores also have their downside. The DOS calls for semaphores are costly in terms of execution. Using the DosSemRequest() call, for example, requires a minimum of 49 assembly language



Listing 1: *Resource.h contains a critical resource definition that includes both a semaphore and a contention counter.*

```
#ifndef LOCALRESOURCE
#define LOCALRESOURCE
typedef unsigned short ushort
typedef unsigned long ulong
typedef struct _RESOURCE {
  ulong Semaphore;
  signed int Contention;
} RESOURCE;

ushort lockResource( RESOURCE *Resource, ulong TimePeriod );
ushort unlockResource( RESOURCE *Resource );

#endif
```

instructions. Semaphores can provide the required synchronization to critical data, but think of the wasted instructions when only one thread needs to use a resource.

Consider an application that has two threads, both of which use the critical data element `NumberOfRecords`. Since both threads may wish to update this variable, I might recognize it as a critical data element and use a semaphore to synchronize access.

A thread must own the semaphore prior to updating the variable, so what happens when thread 1 uses the variable during a time interval when thread 2 is performing I/O? In this situation, I waste 49 instructions to gain ownership of the semaphore, and another 41 instructions to clear the semaphore when I'm done. The problem is, how do I know when there is contention for a resource and when there isn't? If I knew, then I could save the unnecessary calls to both `DosSemRequest()` and `DosSemClear()`.

IBM's M. Kawalec ("Implementing Critical Sections: A Performance Tip," *IBM Personal Systems Developer*, IBM, Summer 1990, pp. 62–65) introduced a contention counter algorithm to address just this problem. The counter lets the thread eliminate `DosSemRequest()` calls unless resource contention occurs. By eliminating unnecessary `DosSemRequest()` calls, the application can reduce the required instructions from 49 to three.

If two or more threads attempt to access the same resource simultaneously, all but one of the threads must issue the `DosSemRequest()`. The algorithm works by setting the counter to -1, denoting the initial state. A thread that wants to use the resource increments the counter and tests its value. The first time it uses the resource, the thread increments the counter from -1 to 0. If another thread needs the resource, it increments the counter to 1. In short, -1 is the initial state, 0 denotes the first access to the resource, and anything greater than 0 indicates resource contention. In that case, all but the first thread must issue a `DosSemRequest()`.

When the first thread no longer requires the resource, it decrements the contention counter. If the counter value is not -1, the thread knows that another thread is waiting for the resource and issues a `DosSemClear()` call to release the semaphore. Note that the semaphore must initially be set with a `DosSemSet()` function call.

Listing 1 contains a type definition called `RESOURCE` that contains a semaphore and a contention counter. Each data structure in the application that is considered a mutually exclusive resource must have a `RESOURCE` type definition as a member. By centralizing the semaphore definition into one location, you can easily change it from a RAM semaphore to a system semaphore for OS/2 2.0.

The Kawalec algorithm has one drawback. It works on the Intel 386 by using the assembly instructions

```
1679 INC Word Ptr ES:[DI+04]
167B JZ 1691 167F
    ....
    <call DosSemRequest()
         ==> 1691
    ....
```

The `INC` instruction sets the status bit and ensures the integrity of the jump past the `DosSemRequest()` call for the first thread requesting the resource. This, however, requires that you compile all sections of code that test the contention counter and call `DosSemRequest()` with the optimization for speed (`-Ot`) option.

Compiling with optimizations disabled (`-Od`) generates a `CMP` instruction between the increment and the jump, which compromises integrity. It is best to implement the Kawalec algorithm by embedding the function in the `lockResource()` and `unlockResource()` functions. By

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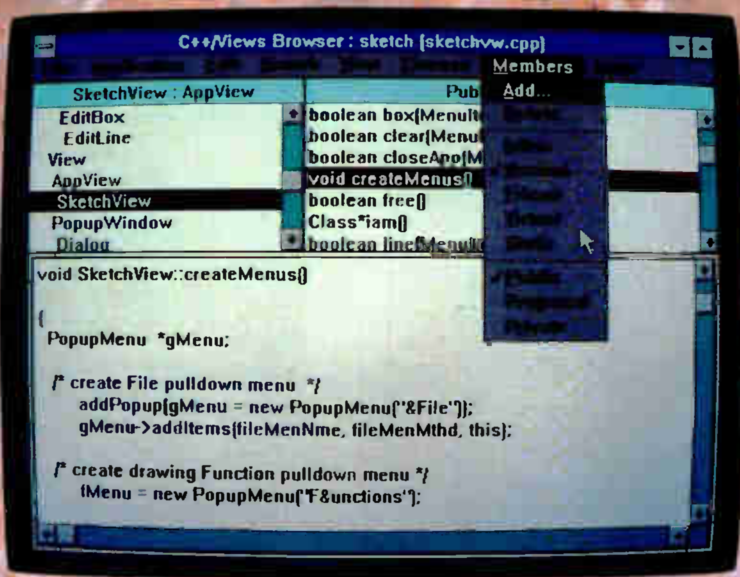

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Listing 2: *Resource.c illustrates the implementation of the* `lockResource()` *and* `unlockResource()` *resource control functions.*

```
#define INCL_DOS
#define INCL_BASE
#define INCL_DOSPROCESS

#include <os2.h>
#include <stdio.h>

#include "attr.h"
#include "state.h"
#include "object.h"

#pragma optimize("t",on)

ushort lockResource( RESOURCE *Resource, ulong
                     TimePeriod )
{
   ushort RC;

   RC = 0;
   if( ++Resource->Contention != 0 )
       RC = DosSemRequest( &Resource->Semaphore,
                           TimePeriod );
   return(RC);
}

ushort unlockResource( RESOURCE *Resource )
{
   ushort RC;

   RC = 0;
   if( Resource->Contention-- != 0 )
       RC = DosSemClear( &Resource->Semaphore );
   return(RC);
}
```

Listing 3: *Tools.h contains macro definitions that help to minimize coding for linked-list manipulations.*

```
#ifndef LOCALRESOURCE
#include "resource.h"
#endif

#ifndef LOCALTOOLS
#define LOCALTOOLS
#define SEMAPHORE  ulong

#define    DEFINE_VIEW(RELATION)                        \
  typedef struct  _##RELATION##View {                   \
              struct  _##RELATION  *Head;               \
              struct  _##RELATION  *Tail;               \
              struct  _RESOURCE     Resource;           \
              } RELATION##VIEW

#define    DEFINE_MEMBER(INSTANCE)                      \
  typedef struct  _##INSTANCE##Member {                 \
               struct  _##INSTANCE *Next;               \
               struct  _##INSTANCE *Prior;              \
               } INSTANCE##MEMBER

#define ADDMEMBER(O, V, M, I)                           \
  (                                                     \
    ( lockResource( &( (O)->V##View.Resource),
                    500 ) ) \
    ? -1                                                \
    : (                                                 \
        (                                               \
          (I->M##Member.Prior =
            (O)->V##View.Tail )                         \
           ?  ((O)->V##View.Tail->
                     M##Member.Next = I)                \
           :  ((O)->V##View.Head = I)                   \
        ),                                              \
        (                                               \
          ((O)->V##View.Tail = I)                       \
        ),                                              \
        (                                               \
          unlockResource( &( (O)->
               V##View.Resource) )                      \
        )                                               \
      )                                                 \
  )
#define SWAIT SEM_INDEFINITE_WAIT
#define REMOVEMEMBER( O, V, M, I) \
(                                                       \
  ( lockResource( &( (O)->V##View.Resource),
                  SWAIT ) != 0 )                        \
    ? -1 \
    : (( \
         ( I->M##Member.Prior )                         \
          ?  (I->M##Member.Prior->
                M##Member.Next =                        \
              I->M##Member.Next)                        \
          :  0                                          \
       ),                                               \
       (                                                \
         ( I->M##Member.Next  )                         \
          ?  (I->M##Member.Next->
               M##Member.Prior =                        \
              I->M##Member.Prior)                       \
          :  0                                          \
       ),                                               \
       (                                                \
         ( I == (O)->V##View.Tail )                     \
          ?  ((O)->V##View.Tail =                       \
             I->M##Member.Prior)                        \
          :  0                                          \
       ),                                               \
       (                                                \
         ( I == (O)->V##View.Head )                     \
          ?   ((O)->V##View.Head =
                 I->M##Member.Next)                     \
          :  0                                          \
       ),                                               \
       (                                                \
         unlockResource( &((O)->
                     V##View.Resource) )                \
       )
      ))                                                \
)

#endif
```

placing these functions into a separate module (`resource.c`), you can use embedded pragmas to ensure that the proper compile options are set.

Unfortunately, there is no mechanism to test whether the `Od` option was specified on the command line, which would disable the optimizations indicated with the pragma. Microsoft Support offers no workaround for that problem. (See listing 2 for the implementation of `lockResource()` and `unlockResource()`.)

The Kawalec algorithm could be written by embedding assembly instructions in your C code via the `_asm` statement. Unfortunately, using that statement disables certain optimizations, such as common subexpression elimination, and some loop optimizations. So I chose to implement `resource.c` as a separate module with embedded pragmas.

Putting Threads to Work

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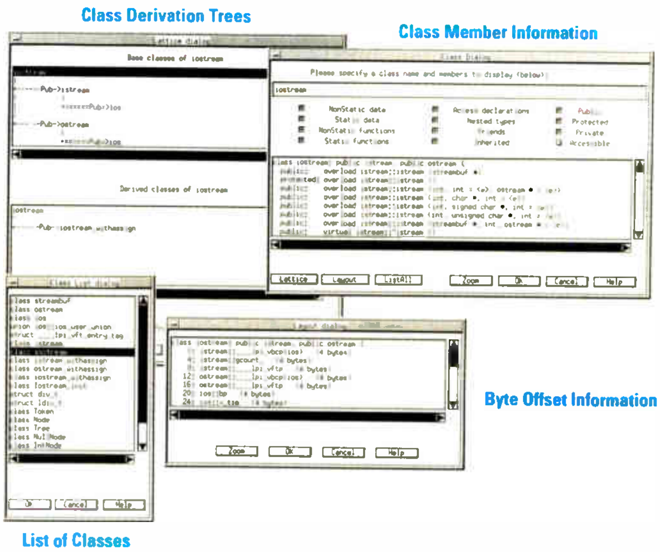

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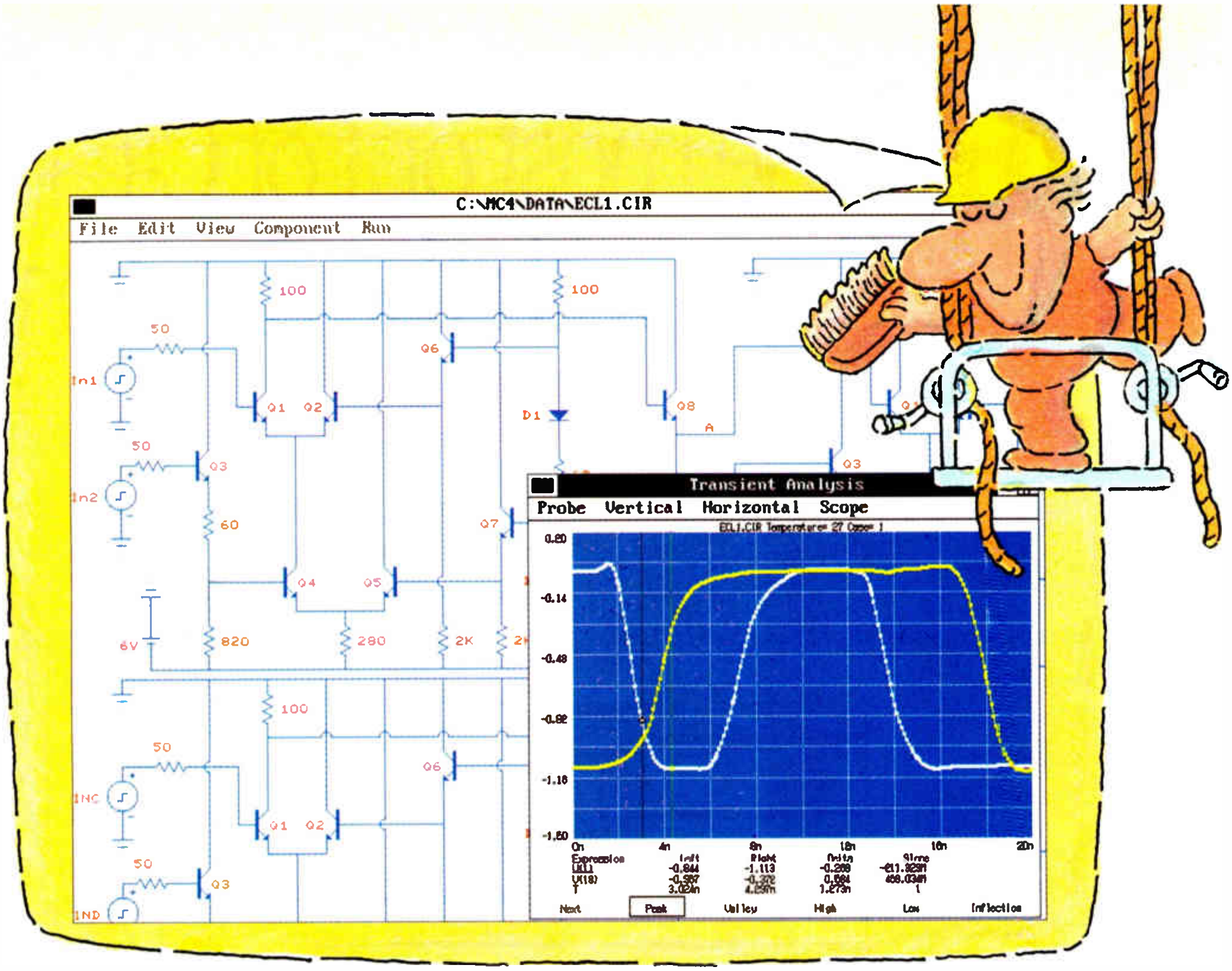

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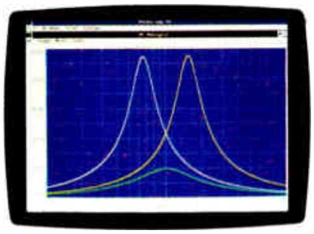

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background I/O. Word processing packages, for example, typically start a separate thread to write work to disk when you select the Save option. The program creates the threads during the initialization routine and remains active until the primary thread ends. While implementations like these can yield performance gains, you can easily extend the use of threads beyond these realms.

The performance benefit of using multiple threads for I/O comes from overlapping computation and I/O processing. The application's primary thread may start up one or more administrative threads as part of its initialization logic, and these threads remain active through the duration of the application. Another use for multithreading is to create many short-lived threads to perform various tasks, such as dynamic memory modeling.

Some application designs perform data administration by executing separate threads, each of which carry out a specific task. Often sophisticated applications have to address the issues of data administration. When completing the hierarchical design model and adhering to structured programming foundations, it is all too easy to declare one box in the hierarchy to be the data management subsystem. Unfortunately, such a design inevitably confuses data management with data administration.

Suppose I am working on a server application that will service requests from multiple clients. Each request the server receives must meet some validity checks before the operating system can service it. The server must complete these checks and fulfill the request before servicing another request. The point is that after the server satisfies the validity checks, it should be immediately available for the next validity check. Developers frequently implement this model using multiple processes and various forms of interprocess communications. This procedure is cumbersome, however, since all the data that the service process requires must be in shared memory or passed by means of message queues. Multithreading offers a clear benefit here.

You can significantly improve complex applications designed for multithreaded environments by separating the administrative aspects of data modeling from the application's design. A well-thought-out application design can clearly delineate the administrative aspects of data modeling (i.e., memory management) from those aspects within the application domain (i.e., the application criteria). Unfortunately, tight schedules, lack of requirements, and even improper designs result in the implementation of hacks that leave the administrative aspects intermixed with the manipulation of the application's data.

Creating a data model using object-oriented programming is cleaner in this respect, but most OOP languages do not provide for dynamic data modeling (Borland C++ 3.0 now offers metaclasses, based on AT&T's C++ 2.1 definition). By *dynamic data modeling* I mean the ability to dynamically select one or more components from existing data structures to create a new data representation. OOP requires that you predefine object types, and this inhibits the use of dynamic data models. A technique called *schema evolution* has been proposed to circumvent this limitation. Database applications also need a method for dynamic data modeling. For example, TRAITE, a DBMS design, introduces a prototype model from which other data types can be derived.

continued

Next month, I will introduce a multithreaded application I call ADAM, for A Dynamic Attribute Manager. You can link this utility with your primary application to take advantage of multithreading. The primary thread can attach simple attributes to data structures, and the attribute manager thread manipulates the data structures based on the attributes attached. But before you dive into ADAM's design, you must understand linked-list manipulations.

Linked Lists

ADAM includes many linked lists that you should know how to manipulate. A linked list offers a common method for administering logically related yet distinct data structures. Each data structure maintains a pointer to the next item in the list. In a doubly linked list, each data stucture also maintains a pointer to the prior item in the list. You should use linked lists for maintaining and administering the physical data structures and for establishing logical relationships between the data structures.

I refer to the linked lists in ADAM as *views*. I define a view as a logical or physical relationship between two distinct data structures implemented as a doubly linked list. I call the data structures themselves *members* of the view.

The view begins with the data structure that establishes the relationships—the *owner* of the view. The owner must define a member data structure that has pointers to the head and tail of the linked list. I also added a resource data structure, called the *<relation>view*, for mutually exclusive updates to the view. Each member in the view must include a data structure to show the next and prior members.

Consider, for example, that the objects must maintain a view of the attached attributes. Therefore, an object type definition includes an *attributeview* data structure that includes pointers to the head and tail of the view. It also includes a resource for mutually exclusive updates to the view.

By standardizing the names for the owner's view and the member's data structures, you can introduce several C preprocessing macros to minimize coding for linked-list manipulations (see listing 3). The macros require that the owner of the view define a data structure with a tag whose name begins with an underscore, followed by uppercase characters (i.e., `struct _OBJECT`). Additionally, the members of the view must be structures with a tag following the same criteria (i.e., `struct _ATTRIBUTE`).

The first macro, `DEFINE_VIEW`, generates type definitions for the view component of the linked list. The `DEFINE_MEMBER` macro generates type definitions for the member components. `ADDMEMBER` adds a new member to a view. `REMOVEMEMBER` removes members from specified views. Note that both of these macros will first request ownership of the semaphore belonging to the owner of the view. If the function issuing the request does not get ownership of the semaphore, the linked list will not be updated.

The `ADDMEMBER` and `REMOVEMEMBER` macros take four arguments: `OWNER`, `VIEW`, `MEMBER`, and `INSTANCE`. The `OWNER` represents the data structure that owns the view, and it contains the head and tail pointers. Since an owner can have more than one view, you must use the `VIEW` argument to specify which view to modify. You must use a `MEMBER` argument, which names the data structures that are members of the view, because a data structure can be a member of more than one view at the same time. The `INSTANCE` argument refers to the member being added or removed from the view.

Several error conditions can arise when adding or removing members to or from a view. You could embed the error recovery in the macro, but this forces all functions to have the same error recovery. I find it easier to have the macro evaluate to zero on success and nonzero on failure. This lets you use the macros in conditional statements, and each function that uses the macros can handle error conditions as deemed appropriate. You could write `if ( ADDMEMBER(Object,Attribute, Attribute,Attribute) );` this would appropriately test to see if the attribute was added to the object's attribute view.

Note that the `ADDMEMBER` and `REMOVEMEMBER` macros make calls to `lockResource()` and `unlockResource()`. You can implement these as near functions to save on the overhead of making a function call. These macros make extensive use of the `:?` operator, and they may confuse you at first. I suggest carefully reviewing them to understand why you need them.

Introducing ADAM

ADAM separates the administrative aspects of data modeling from the primary application through a dynamic attribute manager. The manager administers the data model's characteristics, or *attributes*. ADAM also implements the partitioned tasks using multithreading techniques that enhance performance and simplify the application's design. I introduced a conditional wait routine to provide the synchronization between the application's primary thread and the attribute manager thread.

The application can arbitrarily attach or detach attributes from the representative data to describe its characteristics. ADAM then derives the attribute's value using a predefined attribute procedure.

ADAM also encases a reference to the application's data, along with its attribute information, in a common object data structure. This gives the application direct access to the data while providing the encapsulation of the data's characteristics. If the application data is self-contained (in contiguous memory locations), you can easily transfer it across the network, independently of the attribute information. ADAM does not have any knowledge of the representative data's format, nor does it require such knowledge. Thus, there is a clear distinction between the application's task and the administrative tasks.

The application may, however, require direct information from ADAM. Suppose the application has to wait for the value of a particular attribute to become available. Since a separate thread handles the administration of attributes, there is no guarantee that the value will be available when the application requires it. To circumvent this problem, I supplied a conditional wait function. Through this function, the application can suspend itself until the value is available.

Alternatively, the application can request to wait for the value for a specific time period. It either receives an "available" response or, if the time period expires and the value is still not available, a "time-out" response.

The implementation of ADAM need only occur once, since the manager is similar to an engine. Once implemented, it's reusable; you only need to enhance the attribute set for the particular application. The design of an application system incorporating ADAM can focus on the relevant features to be provided without becoming ensnared in data modeling administration. Once established, a defined attribute is easily reusable between applications. Furthermore, the ability to encapsulate administrative tasks provides a consistent methodology for interfacing in a multithreaded environment.

Next month, I'll discuss the ADAM source code and potential enhancements. ■

Editor's note: *Listings are abbreviated. Expanded and fully commented versions are available in electronic format.* *See page 5 for details.*

Charles J. Northrup is principal of Kingston Technology, Inc., a software services firm in Old Bridge, New Jersey. He is writing a book on multithreaded applications design. You can reach him on BIX c/o "editors."

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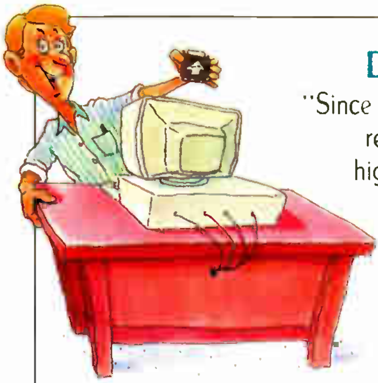

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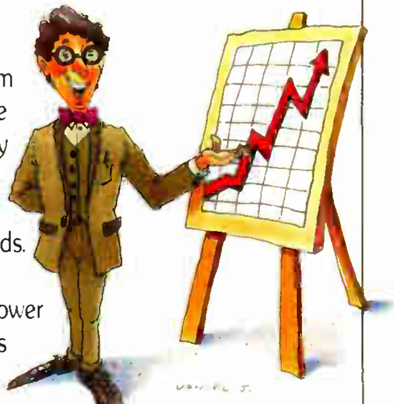

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BARRY NANCE

GETTING FROM BASIC TO C

A classic AI language helps you convert BASIC code to C and offers a glimpse into compiler construction

In the past few years, companies that write compilers have paid a great deal of attention to C. For better or worse, you can reach more platforms and expect better performance optimizations with C than you can with other languages.

Whether you have a small BASIC application you'd like to recode in C or many megabytes of BASIC code you want to port to OS/2, this month's Software Corner is for you. But even if translating BASIC to C is not your top priority, you'll find BASIC-C worth getting if you are interested in compiler technology or Prolog.

BASIC-C, which is written in Prolog, is a compiler that translates BASIC into C. I used PDC Prolog to create the translation utility. PDC Prolog runs under DOS, Windows, and OS/2. If you want to enhance BASIC-C, I suggest that you get a copy of PDC Prolog for $299 from the Prolog Development Center (568 14th St., Atlanta, GA 30318, (404) 873-1366).

The Nuts and Bolts of BASIC-C

Why do I call BASIC-C a compiler? After scanning, lexically analyzing, and tokenizing the input, BASIC-C builds a parse tree of the BASIC source code. (BASIC-C contains commented-out code to display the parse tree during compilation. You can uncomment the code and recompile BASIC-C if you'd like to examine the tree.) Instead of emitting object code, however, the BASIC-C compiler writes C source code.

I used the parser generator in the PDC Toolbox to start the BASIC-C project. The generator turns a Backus-Naur description of your language (BASIC, in this case) into Prolog source code that builds the parse tree. You hook a scanner onto the front of the generated code and a code emitter onto the back of the parser. You then have a compiler. BASIC-C includes the scanner and code-emitter routines and the Backus-Naur description of BASIC.

BASIC is a rich, full-featured language, and BASIC-C doesn't pretend to cover all the bases. If you have a PLAY statement in your program, BASIC-C will flag that statement, and you'll have to manually recode it. BASIC's PRINT and C's `printf` are different, and you'll need to examine the generated code to see if BASIC-C's resulting `print-func` function-call reference is close to what you want.

I applied the 80/20 rule to BASIC-C's design: BASIC-C should be able to automatically compile and translate at least 80 percent of the BASIC statements it encounters. You can handle the other 20 percent. You might simply edit the emitted C source code, or you might modify BASIC-C to handle new BASIC statements. In the latter case, just follow the examples in BASIC-C's Prolog source code.

BASIC-C recognizes a long list of BASIC verbs and functions. These include assignment and expression evaluation, COMMON, DIMENSION, END, STOP, CALL SUBPROGRAM, GOSUB...RETURN, FOR...NEXT, WHILE...WEND, IF...THEN...ELSE, GOTO, LEFT$, RIGHT$, MID$, INSTR, SPACE$, CHR$, LEN, ASC, INT, VAL, INPUT, SCREEN, CLS, and PRINT. ■

MAC/Tom Thompson

Apollo Launches from the Desktop

The solution to a maze of applications, documents, and aliases on a Mac Desktop is an application launcher, a utility that organizes your most-used files and lets you get at them quickly. Good commercial application launchers are available, but Apollo 0.7b2 does the job nicely, and, for the moment, it's free.

This launcher was written by Jeremy Roussak. Apollo is actually two programs, an extension and an application. Apollo pops up a menu of your most frequently used applications, Control Panels, and documents when you press the proper keys and hold down the mouse button. When you select an item from this menu, it responds appropriately; files open, and applications and Control Panels automatically launch. You can reduce menu clutter in Apollo by organizing files into groups. As soon as Apollo comes out of beta testing, Roussak will make it a shareware product. Check it out soon.

UNIX/Ben Smith

Fireproofing Your Bridges

Source files and other documents subject to rapid revision need two kinds of management. First, you must be able to rebuild previous versions to make sure you don't burn your bridges behind you with every edit. Second, you need to maintain a check-in/check-out policy for your files so that you can always be certain what is the "live" version of each document.

Source Code Control System is the traditional set of Unix programs that perform these duties. Revision Control System is a more recent set that is simpler for the user and more robust. Commercial implementations of both systems are available, but one of the best RCS packages is the free version 5 RCS. These tools were designed and built by Walter F. Tichy and are available from the Free Software Foundation. Their source code is also available on most Unix archive sites and on BIX. (Due to program size, RCS is not available from BYTE on disk.)

Editor's note: *Software Corner highlights public domain, freeware, and shareware programs. The programs are available in a variety of formats. See "Program Listings" on page 5 for details. We solicit your contributions. We pay $50 for any program we use. Write to: Software Corner, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

DOUGLAS A. HAMILTON

OS/2 2.0 Goes Down to the Wire

Early this year, IBM introduced what it called the Limited Availability release of OS/2 2.0, which is distinct from the final General Availability (GA) product that should now be available. Is LA a product or just another beta version? Well, it depends on whom you ask. Is LA a better DOS than DOS, a better Windows than Windows, and a better OS/2 than OS/2? Again, it depends on whom you ask.

Different Strokes

For me, LA was the first new release of OS/2 that I did not immediately adopt for day-to-day work. I still prefer version 1.3, but I'm struck by the variety of experiences that users are having with LA. Those with the least previous exposure to OS/2 like it best. The new Mac-like Workplace Shell (WPS) is part of the reason.

IBM's human factors research has shown that new users like the object-oriented, drag-and-drop features of the WPS, and my own observations indicate that that's true. More experienced OS/2 users, on the other hand, are more skeptical. They tend to focus on specific features they've grown accustomed to in previous releases of OS/2—things that the WPS doesn't provide or does differently.

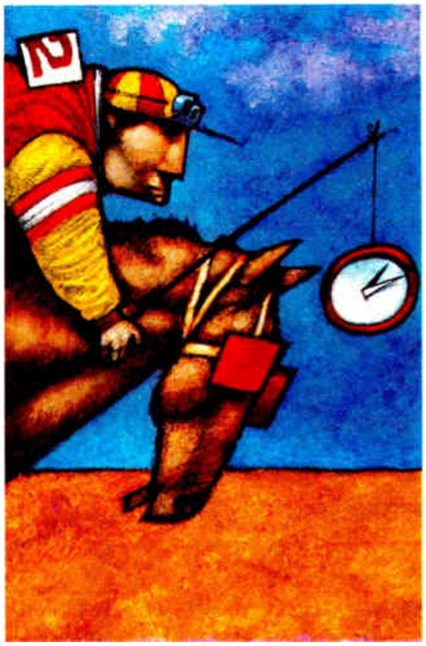
Another factor seems to be the amount of stress that you place on your system. If you have a fairly standard machine and limit yourself to well-known applications, LA looks reasonable. It's certainly better than any previous beta version of 2.0, and most things do work. However, not everything works. Although IBM calls LA a product, it's clearly beta code. More experienced users and developers running OS/2 under even slightly more exotic conditions will almost certainly encounter bugs.

How you react to those defects depends on what you're used to. Existing OS/2 users are spoiled. They've completely forgotten what unreliable junk most of the rest of the world has to struggle with every day. I well remember how reliable OS/2 1.0 was. I just couldn't crash it. And OS/2 1.3 is nothing short of superb: It has never crashed in over a year of my daily pounding. Everything works just as designed, and it's been fast and utterly reliable for the most demanding production work. Thus, for me, a new version of OS/2 that can be crashed is a disappointment.

Those whose past experience has been with DOS or Windows will have, I suspect, a different standard of comparison. If you've been struggling with unrecoverable applications errors that crash your machine twice a day, a version of OS/2 that crashes only once a day might look pretty good.

Finally, the key advantages of version 2.0 are the multiple virtual DOS machines and the ability to run Windows applications. Obviously, these features will be of more value to people with many DOS and Windows applications. These users are, naturally, likely to be new to OS/2.

A developer's reaction to the OS/2 2.0 Limited Availability release



Therefore, as you evaluate reactions to the LA release, here or elsewhere, maintain a skeptical attitude. Different people may have very different experiences with LA, all valid within their own frames of reference.

The OS/2 Roller Coaster

The endless roller coaster we've all been on with OS/2 for the last year makes it difficult to examine LA in any sort of detached way. At times, it has appeared that success for OS/2 was just around the corner. At other times, it has looked as though things could not get worse. Through much of last year, IBM successfully exploited discontent with Microsoft, positioning itself as the good guy. It could be trusted to stay the course and deliver on its promises.

But that wave is now coming to shore. IBM is riding it right up onto the beach. We've been standing here cheering, and it's now time for IBM to deliver. With Microsoft's NT looming on the horizon, apparently more real than many of us expected just last fall, IBM is under intense pressure. That pressure also falls on those who have bet their fortunes on OS/2.

By releasing LA, IBM has minimally kept its promise of shipping OS/2 2.0 as a product by the end of 1991. But by calling it a product, IBM has also invited some close scrutiny.

Workplace Shell a Gamble

The WPS raises some interesting questions. In its present state, it just isn't quite ready. IBM could have counted on almost certain success without the WPS, so it's fair to wonder if it should have gambled the entire version 2.0 introduction on this new and unproven technology.

continued

ILLUSTRATION: TEO PITTS © 1992

According to one report, IBM believes the WPS will be the one part of version 2.0 not covered by its joint development agreements with Microsoft. If the WPS succeeds, it will give IBM at least a two-year lead over Microsoft.

Whatever the reason for IBM's decision, the choice was made, and, at least in LA, there is no going back. IBM does offer tips on configuring the WPS to look similar to the old Presentation Manager (PM) shell, but the similarity is only cosmetic, not functional, and even then not very complete. (I'm told that GA may allow more complete emulation of the older interface.)

There are many reasons to like the new WPS. The desktop is easily customized with icons for your applications. The online help facility is dramatically improved, featuring a Master Help Index organized like a spiral notebook with little tabs for each letter in the alphabet. Click on a topic, and up comes a hypertext window with generally well-written explanations.

Everything is bound together with a clever drag-and-drop metaphor. To change the color of something, you drag the new color over from a rainbow palette. Changing a font is just as easy. To delete something, you just drag it to the shredder. The vision behind the WPS leads to an environment in which all sorts of tasks can be accomplished by dragging and dropping.

The Workplace Shell is more promise than reality in LA.

To fill out a form, for example, you'd drag a record out of a database and drop it onto a form.

The problem is that the WPS is more promise than reality in LA. It's not always intuitive. Ordinary operations involve various odd combinations of Shift keys and left or right buttons. A little "cheat sheet" with all the key bindings would help. Everything seems to take more keystrokes and mouse-clicks than under the old shell.

The implementation also feels fragile. A lot of the WPS "state information" is kept in extended attributes or hidden binary files with strange names. Lacking tools for repairing or even examining these structures, I worry that the slightest failure might force me to reformat and reinstall the system.

Finally, while the WPS is dramatically improved from the earlier beta versions, it's still somewhat slow and buggy. Because there's no way to avoid using it, that makes the whole system seem slow and buggy. Booting the system takes a long time, and text windows are not fully reliable. IBM has made enormous progress with the WPS since its introduction, but the question is whether there's sufficient time to fully stabilize it for GA.

DOS Boxes Overdesigned?

One nice feature of OS/2 2.0 is support for multiple virtual DOS machines. In contrast to the version 1.3 DOS box, version 2.0 lets you open as many DOS windows or full-screen sessions as you want. Each can be configured with a big memory, load

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special device drivers, and even mimic specific releases of DOS. IBM often demonstrates DOS games and other demanding software in the VDMs. Nothing in my experience with LA makes me doubt the quality of version 2.0's virtualization of DOS.

I admit, however, to a nagging concern that IBM may have overdesigned the VDMs, solving a problem that didn't really exist. Clearly, the version 1.x DOS box fell short of people's needs. Users do need extended and expanded memory, and they do want to run more than one application at a time. But how much is enough? Does it really matter whether some obscure DOS game software runs under OS/2? The world is changing, and, increasingly, it's becoming a Windows world.

A Better Windows?

Support for running Windows applications in a separate full-screen session is built into this release as the first step toward "seamless Windows" in the upcoming GA. By *seamless*, IBM means that Windows and PM applications will share a common desktop.

When I first tried the Windows support on my PS/2 Model 80, I was appalled. It couldn't even keep up with the mouse. Then I discovered that on another machine—a PS/2 Model 70—Windows ran almost indistinguishably from Windows on DOS. Eventually, I found that the problem was with the 8514/A display on my Model 80. In the DOS settings for Windows Full Screen, the default traps all the 8514/A and Extended Graphics Array calls into software; turning that off fixed the performance problem. Unfortunately, it created a different problem with screen repainting. So for now, there are still problems with 8514/A support, although I wouldn't be surprised if they'll be fixed by the time you read this.

Sources inside IBM assure me that the seamless Windows support in GA will be much faster than in LA, perhaps only 10 percent slower than Windows on DOS. They claim they've already achieved this on some of their internal versions.

Moment of Truth

On the whole, IBM might have been better off not releasing LA as a product, limited or otherwise. It's buggy, it crashes, and it's not as dependable as any previous OS/2 product release. Viewing it as a beta version, I can put these problems in perspective. But even so, I'd be more comfortable if GA weren't looming so close.

The first order of business for IBM has to be quality. An OS/2 that crashes isn't a better OS/2 than OS/2, much less anything else. Quality is and will continue to be the single biggest obstacle to gaining support from existing OS/2 users who have been spoiled by version 1.3. Businesses considering it for mission-critical applications will require rock-solid reliability.

Sources inside IBM promise me that GA will show great improvement and be all you could ask for. I trust them, I trust their judgment, and I believe they have seen internal versions that support those views. There's a good chance for IBM to achieve enormous success with a blockbuster GA release. But there's not much time left; it's going to be close. ■

Douglas A. Hamilton is the founder of Hamilton Laboratories in Wayland, Massachusetts, and the author of the Hamilton C Shell, a command processor and utilities package for OS/2. He can be reached on BIX as "hamilton."

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CARD 104

ASK BYTE

Setting a Page Frame

I have a problem getting EMM386 to run. The following lines are in my CONFIG.SYS file:

```
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE
```

When I boot up, my PC displays the error message "Seitenrahmenadresse kann nicht gesetzt werden." In English, this translates roughly to "Frame address cannot be established."

I'm also getting the message "Fast A20 gate enabled" from my BIOS.

Christopher Kukulies
Aachen, Germany

The error message means that EMM386 can't find a page frame. EMM386 needs 64 KB of contiguous free memory between C000 and EFFF hexadecimal in which to emulate EMS. Your system has probably mapped ROM into the C000, D000, and E000 memory-address blocks.

You can snoop around memory with utilities like Quarterdeck's Manifest or Microsoft Diagnostics (available on BIX as MSD100.LZH in "ibm.utils/listings"). If you have 64 KB of contiguous space, tell the device driver where to find it. For instance, if C000–CFFF is free, use `DEVICE=EMM386.SYS RAM FRAME=C000`.

If you have 64 KB free in noncontiguous areas, you'll have to rearrange the memory assignments of your other add-in cards. On a Micro Channel machine, you can run the Setup utility on the reference floppy disk. On an ISA machine, you'll probably have to set jumpers or switches. The page frame must start on an address that's divisible by 400h.

The "Fast A20 gate enabled" message means that your computer is capable of using the newer PS/2 method of switching in and out of protected mode, rather than the older IBM AT method used with the 286 processor. This switch enables and disables access to memory above 1 MB.

The IBM AT method toggled the A20 gate by sending command sequences to the keyboard controller. The PS/2 method lets your machine write a single byte to an output port to enable and disable access—a much quicker method.

The HIMEM.SYS driver can use either switching method. Check your DOS documentation for specific machine support.—Raymond GA Côté

Lightning Strikes Twice

I have a Tandy 3000 NL 286 computer connected to a 486/33 tower configuration with a null modem cable. Last month, a lightning surge hit my setup. Both machines were off at the time. Now, neither machine's printer port works.

I had no printer on the 486/33, but I did have one connected to the NL 286. I have tried three different printers and a new printer cable, but I still get this error message on both machines: "Errors on list device indicate that it may be off-line. Please check it."

I can see why the Tandy's printer might have been affected, because it was connected when the lightning surge hit. However, I don't see why the 486/33's printer port should be damaged. The printer port on the Tandy is on the motherboard and is probably not worth fixing. The 486/33 has a multi-I/O card with serial, parallel, and IDE hard drive ports.

Christine McGonagle
West Wareham, MA

A strong lightning surge will jump over a turned-off power switch, across serial cables, and through telephone lines to your modem—through any connection it can find. The only sure way to protect your machines during serious power surges is to unplug them and disconnect any modem lines. The fact that your printer port on the 486/33 tower configuration wasn't connected is a red herring; it's on the same multi-I/O card as the serial port.

Replacing the 486/33's multi-I/O card should take care of the problem. There's a good chance that the 286's printer port is damaged, too, and, as you say, it may not be worth repairing. Integrating everything into one board has some disadvantages.—Howard Eglowstein

Nosy Questions

I am looking for a software package that's specially written for plastic surgeons operating on the nose. As far as I am aware, the plastic surgeons in America use this in determining the best shape of the nose.

M. Seif
London, U.K.

The annual MD Computing Buyer's Guide *lists medical software. It's available for $7.95 from Springer-Verlag (44 Hartz Way, Secaucus, NJ 07094, (212) 460-1500).*
—Raymond GA Côté

RAM Drive Rebuttals

I would like to answer Stan Wszola's concerns about using a large RAM drive, in his reply to my letter in the January Ask BYTE. The database application I am running is not sensitive to a RAM drive configuration.

The computer has a 4-MB cache for the hard drive, which has a 9-millisecond average access time, and we have all our computers on an uninterruptible power supply (UPS). This ensures a glitch-free voltage supply and provides [illegible]0 to 40 minutes of power. After the mains have been lost for 5 minutes, we go to our own generator.

Our UPSes trip on several times a week, and we have provided our own power for as long as 100 hours at a stretch. In the last several years, we have not lost a bit of data or a hard drive.

T. Pappan
Owosso, MI

In the January Ask BYTE, T. Pappan requested a RAM disk greater than 16 MB. Although our current documentation says that MS-DOS 5.0 supports RAM disks of from 16 KB to 4 MB, MS-DOS 5.0's RAMDRIVE.SYS can support RAM disks of from 4 KB to 16 MB using Extended Memory Specification memory and up to 32,767 KB (32 MB − 1 KB) using EMS memory.

Brad Chase
Group Product Manager, MS-DOS
Microsoft Corp.

Missing Fonts

I am looking for font cartridges for my Epson/Apex L-1000 24-pin dot-matrix printer. Do you know where I can find them?

Howard Sheldon
Prescott Valley, AZ

Contact Epson Accessories Sales at (800) 873-7766. Epson sells single-font and multiple-font cartridges. The multiple-font cartridges work only with newer Epson printers. Run your printer's self-test. If the message "N9" appears, multiple-font cartridges will work fine.
—Raymond GA Côté

Model 50 Shows Its Colors

I have an IBM PS/2 Model 50 and would like to see more than 16 colors on its 640- by 480-pixel VGA display. Is there any easy way to add more memory to the VGA, thereby letting it display 256 colors with a display resolution of 640 by 480 pixels?

Joel Schneider
St. Louis Park, MN

Considering the speed of your 8-MHz 286 and the cost of upgrading it, you might be better off selling it and buying a new one. The PS/2 VGA subsystem on the motherboard cannot be upgraded, but you can replace it. STB Systems (1651 North Glenville, Suite 210, Richardson, TX 75081, (800) 234-4334 or (214) 234-8750; fax (214) 234-1306) sells the PowerGraph ERGO-VGA/MC Super VGA board for the PS/2 and other Micro Channel machines. It comes in 512-KB ($390) and 1-MB ($459) versions, and it offers Video Electronics Standards Association–compliant high-resolution modes of up to 1024 by 768 pixels with up to 32,768 colors. It should solve your problem nicely.—Howard Eglowstein

Beyond Valdocs

I have an Epson QX-10 running Valdocs 1.19. Even though it's very old and slow, it's easy to use. I want to buy a faster machine (a 33-MHz 486), and I'd like to know if any PC software works like Valdocs.

Harry Gottschall Jr.
Montoursville, PA

The early 1980s were an interesting time for computer designers. There wasn't much standard hardware, so many manufacturers made specialized equipment. The QX-10 was one such product, with special dedicated key caps for different functions. One of the details that made using Valdocs so easy was that to do things like italicize text, you simply pressed the italic key. There were no annoying pull-down menus and such. I still use one of my favorite word processors designed that way—the Canon Cat. Having standard machines like the PC, Mac, and Amiga makes things easier for programmers, but they lack some of the functionality you get from dedicated hardware.

It's time to move on. Your 486 system is likely to run Windows, and you'll learn to use the menus and mouse as easily as you used Valdocs.

Most of the major word processing vendors have offerings for Windows, and there are drawing packages galore. Many of them do things that the old CP/M QX-10 could only dream about. Once you get over the learning curve, I think you'll be much happier for the effort.
—Howard Eglowstein

Keyboard Ergonomics

I am looking for a keyboard designed to reduce wrist strain and the possibility of repetitive-strain injury. I've looked everywhere and cannot find any information. What products are available?

Stuart Stern
Chatsworth, CA

Although this issue has received much attention, strain-reducing keyboards are still difficult to find. David Wesson of San Jacinto, California, is an independent designer who developed a keyboard that's bent into a wave shape and maintains your wrist in a natural position. Unfortunately, this keyboard is not yet being manufactured.

Another approach is to use chordic keyboards, such as those from Infogrip (812 North Blvd., Baton Rouge, LA 70802, (504) 336-0033; fax (504) 336-0063) and Handykey Corp. (141 Mount Sinai Ave., Mount Sinai, NY 11766, (800) 638-2352 or (516) 474-4405; fax (516) 474-3760). Infogrip's seven-key Bat keyboard supports and angles your wrist in a comfortable position. Handykey's Twiddler is a 12-button keyboard that combines the flexibility of a mouse and a keyboard. Although it's not designed to reduce injury, the Twiddler has the advantage of not being tied to a tabletop; you can hold it comfortably in your hand.

The most economical choice is still a wrist-support pad, a version of which can be found in most computer stores. These pads provide a cushion in front of your keyboard on which you can rest your wrists while you are not typing. When typing, however, you should still keep your wrists elevated above the pad. ■
—Raymond GA Côté

The BYTE Lab welcomes your questions. Address correspondence to Ask BYTE, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. You can also send BIX mail c/o "editors."

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TOSHIBA T1000LE/SE/XE/T2000/T2000SXE/T2200SX 2MB UPGRADE (70ns)	$158
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ZEOS 286/386SX NOTEBOOK 2MB UPGRADE	$98
ZENITH MASTERSPORT 386SX/SL/SLE 2MB UPGRADE	$128

LASER PRINTER MEMORY

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BROTHER HL-8E/8D/8V 2MB UPGRADE	$158
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EPSON EPL-6000 2MB/4MB UPGRADE	$128/$218
EPSON EPL-7000 2MB/3MB UPGRADE	$148/$188
FACIT P6060 2MB/4MB UPGRADE	$138/$218
HP LASERJET II/IID 2MB/4MB UPGRADE	$128/$218
HP IIP/IIP+/III/IIID/IIIP/LASERJET FAX 2MB/3MB/4MB UPGRADE	$118/$158/$198
HP LASERJET IIIsi 1MB/4MB UPGRADE	$98/$178
HP DESKJET+/500/500C 256K UPGRADE	$68
HP LASERJET FAX 1MB UPGRADE	$78
IBM/LEXMARK 4019/4019e 2MB/3.5MB UPGRADE	$128/$198
IBM/LEXMARK 4029 2MB/4MB UPGRADE	$108/$168
KYOCERA F800/F800A/F800T 2MB/4MB UPGRADE	$148/$238
KYOCERA F1200S/F3300/F3300A 2MB/3MB/4MB UPGRADE	$168/$208/$248
MANNESMANN TALLY 905 2MB/4MB UPGRADE	$138/$218

MORE PRINTER MEMORY

NEC SILENTWRITER 2 MODELS 90/290 2MB UPGRADE	$168
OKIDATA OKILASER/400 2MB UPGRADE	$128
OKIDATA OKILASER 800/820 2MB/3MB/4MB UPGRADE	$148/$188/$228
OKIDATA OKILASER 830/840 2MB UPGRADE	$168
OLIVETTI PG-108/PG-208 2MB/4MB UPGRADE	$138/$218
PACKARD BELL PB-9600 2MB/4MB UPGRADE	$138/$218
PANASONIC KX-P4420/KX-P4450i 2MB/3MB/4MB UPGRADE	$128/$178/$218
PANASONIC KX-P4455 2MB UPGRADE	$158
QMS PS410 2MB/3MB/4MB UPGRADE	$148/$188/$228
QMS PS815/PS825 2MB/4MB/6MB UPGRADE	$178/$268/$348
SHARP JX-9500PS POSTSCRIPT 1MB UPGRADE	$98
STAR LASER PRINTER 8 2MB/4MB UPGRADE	$188/$268
STAR LASER PRINTER 4 2MB/4MB UPGRADE	$198/$288
TI MICROLASER, PS17, PS35 & MICROLASER/XL 1MB UPGRADE	$68
TOSHIBA PAGELASER6 2MB/4MB UPGRADE	$138/$218
UNISYS AP9210 2MB UPGRADE	$128

HARD DISK DRIVES

CONNER 2024 2.5" 20MB IDE HARD DRIVE	$128
CONNER 2044 2.5" 40MB IDE HARD DRIVE	$248
CONNER 2064 2.5" 60MB IDE HARD DRIVE	$328
CONNER 2084 2.5" 80MB IDE HARD DRIVE	$398
CONNER 3204 3.5" 212MB IDE HARD DRIVE	$748
TOSHIBA TC2124 2.5" 130MB IDE HARD DRIVE	$688

BATTERY-POWERED EXTERNAL DRIVES

BATTERY-POWERED 20MB EXTERNAL HDD	$278
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3.5" EXTERNAL FLOPPY DRIVE FOR
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SHARP PC-6220
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(while supplies last)

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TI TRAVELMATE TM2000
COMPUADD COMPANION
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SE HABLA ESPANOL
(Pregunte por Hector)

Please note that
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is listed in the Toshiba Technical Information Guide (TIG) as the least expensive memory manufacturer approved by Toshiba America

tote-a-lap

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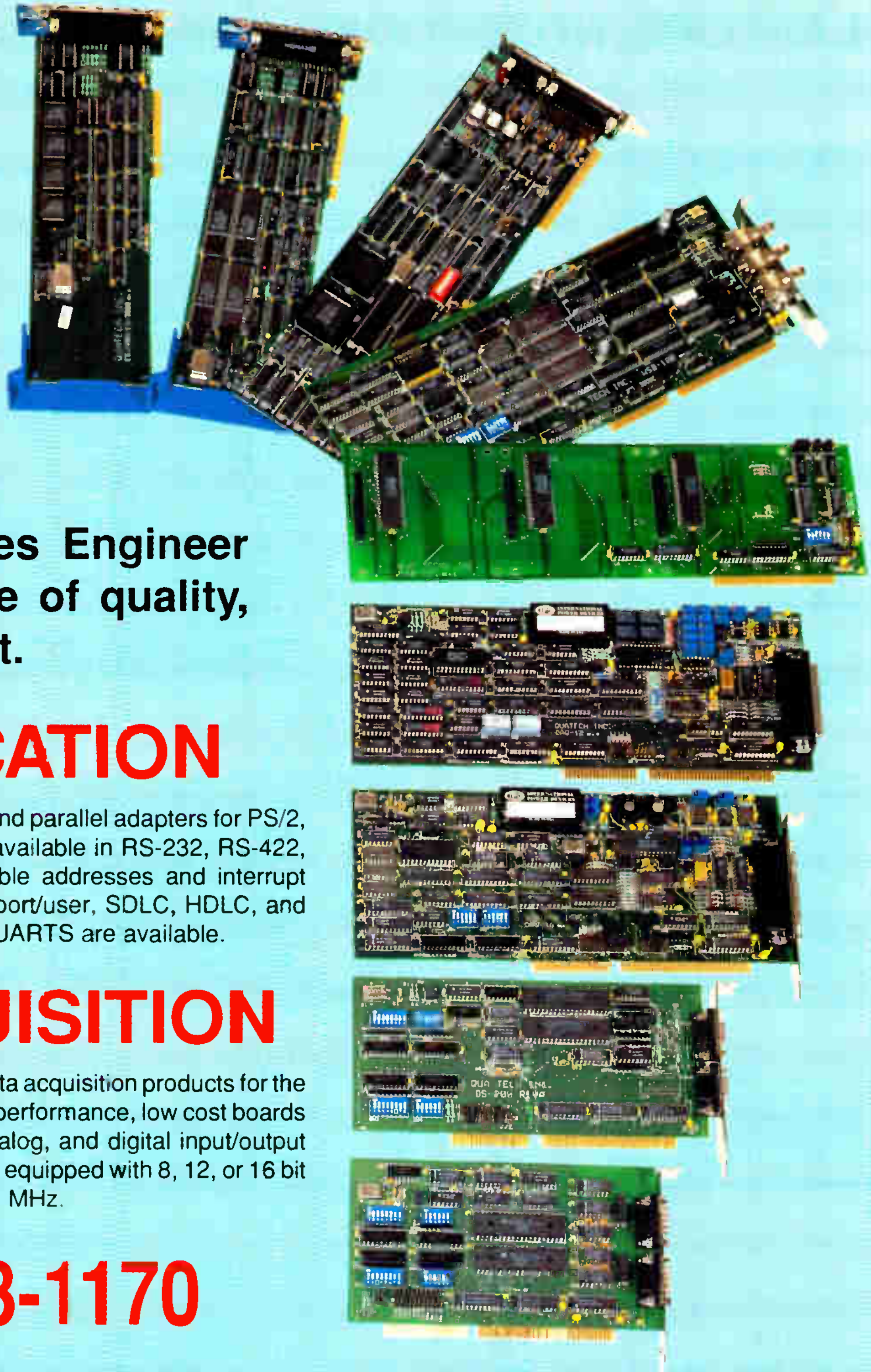

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COMMUNICATION

Quatech produces a full line of serial and parallel adapters for PS/2, PC-XT, AT and compatible systems available in RS-232, RS-422, RS-485 and Current Loop. Selectable addresses and interrupt capabilities are featured in our multi-port/user, SDLC, HDLC, and X.25 adapters. Software and 16550 UARTS are available.

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Quatech has developed a full line of data acquisition products for the IBM AT and compatibles. These high performance, low cost boards provide analog-to-digital, digital-to-analog, and digital input/output functions. A/D and D/A converters are equipped with 8, 12, or 16 bit resolution, and sampling rates up to 1 MHz.

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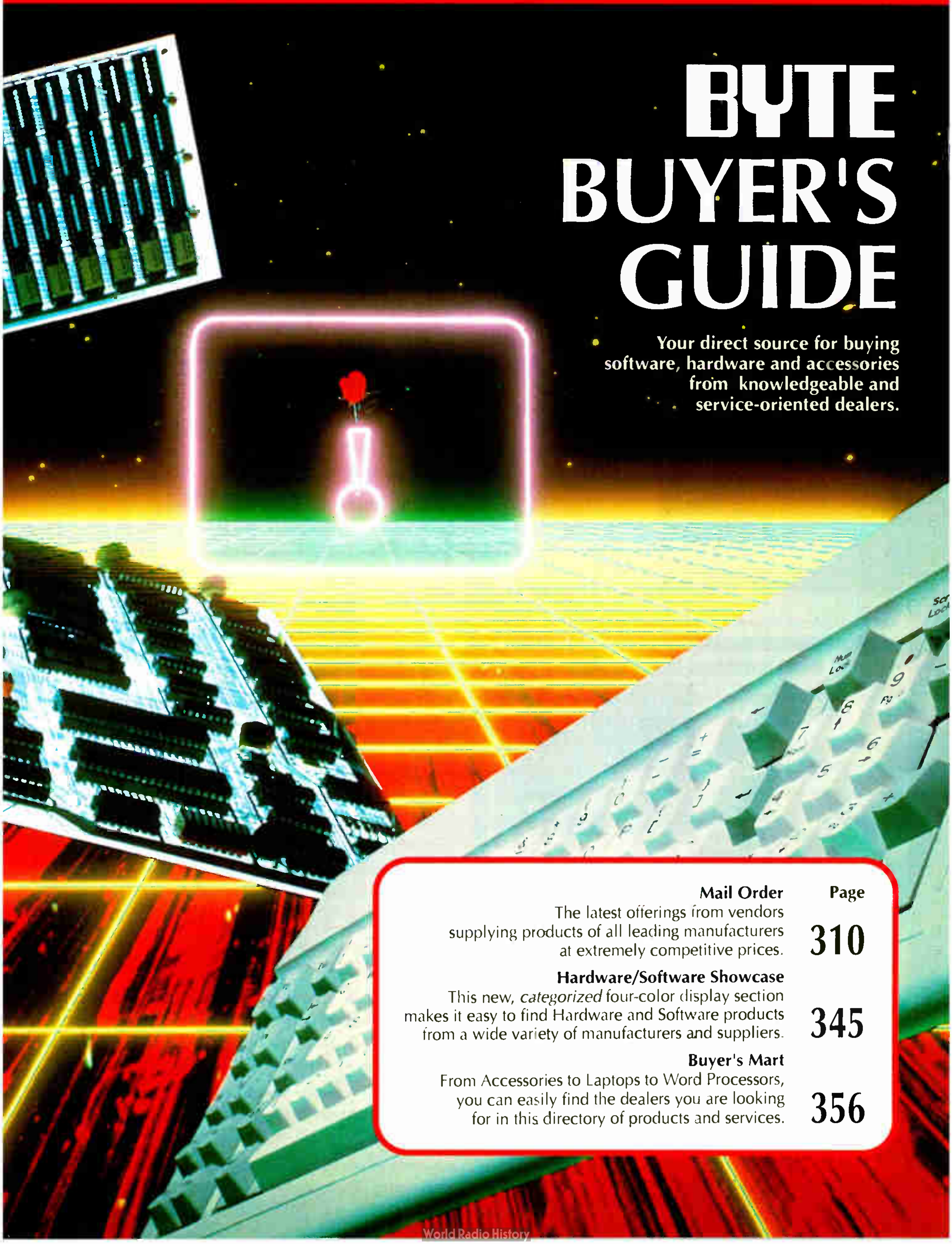


BYTE BUYER'S GUIDE

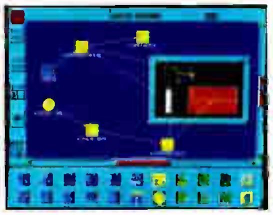
Your direct source for buying software, hardware and accessories from knowledgeable and service-oriented dealers.

CyberResearch System of the Month Features RTI DAS from Analog Devices

Package includes Labtech Notebook

The **RTI** series of data acquisition boards were designed by **Analog Devices** with industrial users in mind. With the lowest MTBF in the industry, these are the boards to chose when reliability is critical. Designed from the outset to be compatible with the full line of Analog Devices' signal conditioning modules, these boards can be used for the broadest possible range of data acquisition applications.

CyberResearch has now made this top-of-the-line product affordable for everyone. By bundling an **RTI 815A** together with **Labtech Notebook** software at one low price, we've saved over $500 and made it possible for you to afford the very best.



Labtech Notebook

Each combination package contains:

- **RTI 815A** DAS board configured for 32 S.E. or 16 Diff analog input channels with 50KHz A/D conversion rate, 2 analog output (D/A) channels, 16 Digital I/O and 3 Counter/Timer I/O.
- **Labtech Notebook** menu-driven software with new IconView diagramming user interface and drivers for the RTI 815A board.

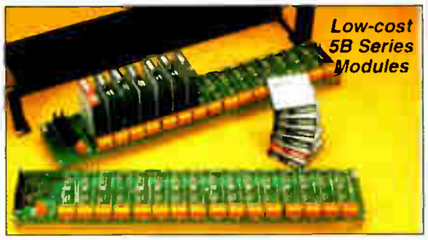
#RTI 815LN RTI DAS Combination Package $1995

Guarantee Valid Data with Signal Conditioning Modules

Signal conditioning modules serve several purposes: they protect your computer, isolate your signal of interest from noise, amplify low-level signals, and provide power and excitation to transducers.

One name is virtually synonymous with signal conditioning: **Analog Devices**. And CyberResearch is your Analog Devices distributor carrying every signal conditioning line: the versatile **3B** series, the low-cost **5B** series, and the new, intelligent **6B** series with on-board A/D conversion.

Call to receive additional information.



Circle 300 on Inquiry Card.

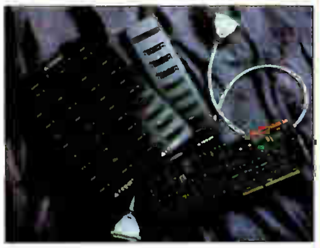
EasyPlot II Scientific Graphing Software

Are you tired of using Lotus to create scientific plots? Now **EasyPlot II** helps you create complex graphs and detailed 3-D plots from your data. Easy-to-use **EasyPlot II** is completely menu-driven. Analysis functions, unlimited display options and journal-quality output make this the package of choice. Makes a perfect companion to our Labtech Notebook data acquisition software.

#SPS 215 EasyPlot II Scientific Plotting and Graphing Software $349
#SPS 218 EasyPlot II Software (SAVE $50 when purchased with Labtech Notebook)..... $299

Arnet Intelligent Serial Boards

Your PC is no longer limited to 2 serial ports! Multi-port serial boards from Arnet let your PC support up to 66 serial ports. All Arnet boards come complete with DOS Driver Software and an external 25-pin "D" connector box.

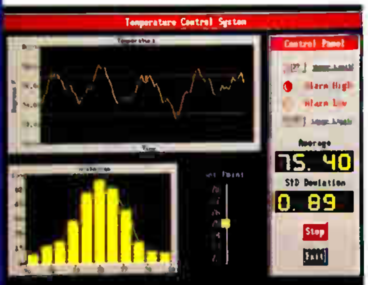


- Intelligent units offer on-board microprocessor and dual-ported RAM.
- **Free** driver software lets DOS recognize up to 66 COM: ports.
- 'Rock-Solid' **Lifetime Warranty**
- **SurgeBlock**™ on all ports protects your PC from killer voltage spikes.

#COMH 104 4-Port Intelligent Serial Board $595
#COMH 108 8-Port Intelligent Serial Board $995
#COMH 116 16-Port Intelligent Serial Board $1895

LabWindows 2.0 Instrumentation Software

With **LabWindows 2.0** you get the best of both worlds: the ease-of-use of a menu-driven package combined with the flexibility possible only when you write your own code. The menu interface takes you through the process of configuring the data acquisition, analysis, & display portions of your system. ***It then compiles your setup into C or QuickBASIC code.*** This is the easiest way to create data acquisition & analysis programs!



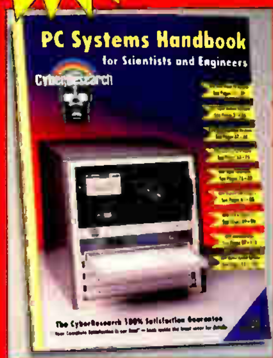
#NIS 473 LabWindows 2.0 Software System.................... $695
#NIS 474 LabWindows 2.0 Advanced Analysis Library..... $895
#NIS 475 LabWindows 2.0 Acquisition + Analysis (both) . $1495

Circle 302 on Inquiry Card.

CyberResearch May

FREE

PC Systems Handbook for Scientists & Engineers



This Combination Tutorial/Catalog Includes Many Examples of PC-based Scientific & Engineering Systems

Have you wanted to enjoy the many benefits of configuring your own PC-based Data Acquisition or Instrumentation system, but didn't know where to begin? The **PC Systems Handbook** will lead you every step of the way, explaining all aspects of systems configuration with easy-to-understand text and clearly documented diagrams. A detailed glossary and two dozen "Tech Notes" help you understand the terminology. Our new **1992 Edition** will be expanded to 196 pages with a hard spine, making it suitable as a permanent addition to your bookshelf. And there is **absolutely no charge** for this invaluable reference book delivered within the United States. A handling charge is required for Handbooks sent overseas. Please call or Fax for information.

Topics Covered Include:

- **Industrial Rack-Mount PC's — AT, 80386, & New 80486 Models**
- **Real-Time Data Acquisition, Analysis, & Process Control Software**
- **PC Plug-in Boards for Analog/Digital, Digital/Analog, & Digital I/O**
- **Connect your PC to Test Instrumentation with IEEE-488, RS-232, RS-422**
- **Stepping and Servo Motor Control with your Personal Computer**

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Notice to International Customers

You can buy direct from CyberResearch and **save 50%** or more! A majority of the leading brands of PC-based engineering products are available for export from CyberResearch at the same low prices as those enjoyed by our customers in the United States.

Due to contractual restrictions, products from some manufacturers are not available for export to certain countries.

Please fax a request for quotation listing brand and/or performance requirements, and we'll fax back a prompt response.

Elma Rack-Mount Keyboards

If you use a standard keyboard with your rack-mounted system, you know what a nuisance and a hazard it can be. These new industrial keyboards are designed to fit easily into any EIA 19" rack. Rugged and reliable, these keyboards are made in the U.S.A. by a Swiss company and demonstrate classic Swiss craftsmanship.

- Full 101-key layout.
- Full-travel construction with excellent tactile feel for touch-typing.
- **OIX 3010** keyboard is set in a drawer (not shown).
- **OIX 6010** keyboard slides out w/ a locking door.
- Occupies only 1 rack space (1.75" high).

#OIX 3010 Rack-Mount Keybd — 24" D Rack....**$295**
#OIX 6010 Rack-Mount Industrial Keyboard......**$395**

100 MHz PC-Based Scope

CompuScope 250 from **Gage Applied Sciences** is a family of high quality 100 MegaSPS PC/XT compatible Data Acquisition Cards with advanced oscilloscope software. Features include:

- 100 MHz sampling on one channel or 50 MHz simultaneous sampling on two channels
- 8-bit resolution
- 50 MHz bandwidth
- 32 or 128-KiloByte memory buffer
- Programmable gains
- Store and load setups and signals
- Drivers available in C, Pascal and Basic.

#DSO 250L 100 MHz CompuScope 250 Lite....**$2750**
#DSO 250-32 100 MHz Scope w/32K Buffer.......**$3495**
#DSO 250-128 100 MHz Scope w/128K Buffer.....**$3895**

Circle 303 on Inquiry Card.

VGA to your VCR

Tape VGA Animation

Redlake TapeCaster VGA to Video Converter

Redlake's **TapeCaster** converts VGA screen output to video for applications such as animation and creating training tapes. The TapeCaster is extremely easy to use: no base addresses, no interrupts, no software — just plug and play.

- True, precise NTSC or PAL video timing
- Simultaneous VGA and video display
- Composite Video & Y-C (SuperVHS) output for use with equipment ranging from an inexpensive VCR to broadcast-quality professional video.

#NTSC 200 TapeCaster – NTSC Video Output... ....**$750**
#PAL 200 TapeCaster – PAL (Europe) Video Out. ...**$750**
#NTSC 100 NTSC Video Digitizer w/software **$1650**

Product Showcase

PC Products for Scientists & Engineers

When you need PC-compatible equipment for science and engineering, there's only one name to think of: **CyberResearch**. We offer the largest selection of hardware and software for data acquisition, instrumentation, communications, motion control, etc. We stock all your best-known suppliers like those featured on these pages and many more.

FREE Application Engineering

At CyberResearch we have no salespeople. Our engineers have one priority: to help you find the best technical solution to your problems. Calling our Applications Hotline is like having your own free consultant. Call and let our experience work for you.

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A/D acquisition
D/A output
Digital I/O
Strip chart
PID
A/D to file

Generate waveforms

Display
Draw graph
Overlay graph
XY graph
Axis plot
Waterfall plot
Scroll from memory or disk
Zoom in on data
Graph labels

Input/Output
Create data table
File operations
PCX file I/O

Set colors
Memory locations
Data manipulations
Select screen area
Select axis style

#ASY 100 EASYEST AG — All these features for a remarkably low price: **$395**

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Low-Cost Data Acquisition with the PCL 812

New A/D boards from **Advantech** have made data acquisition more affordable. Despite their low cost, these boards have not sacrificed performance or advanced capabilities. Our complete packages give you everything to set up your PC as a data acquisition station.

Save with PCL812 Complete Packages!

- 16 Single-Ended Analog Input Channels and 2 Analog Output Channels.
- Up to 30,000 Samples Per Second with 12-bit Resolution.
- 16 Digital Input Lines and 16 Digital Output Lines

#PCL 812 30 KHz, 16-Channel, Low-Cost A/D Board w/ BASIC SW Drivers. ...**$395**
#PCL 812G PCL 812 with Software-Programmable Gain Levels **$495**
#PCL 812LT Package of PCL 812, Labtech Notebook SW & Terminal Panel.... **$1295**
#PCL 812GLT Package of PCL 812G, Labtech Notebook SW & Terminal Panel **$1395**

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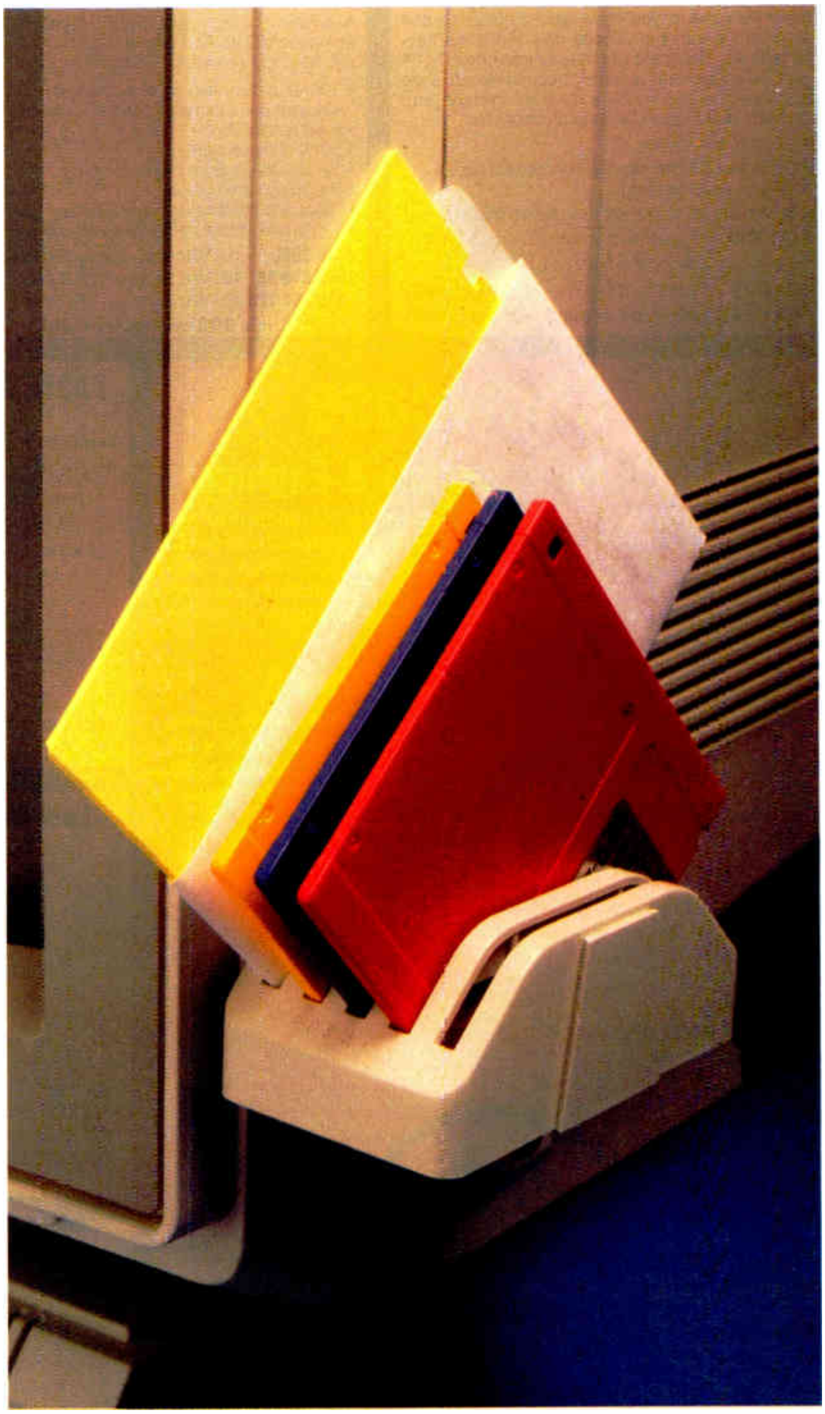
Rugged, Industrial Rack-Mount PC's

These are the toughest PC's available **anywhere**. Each unit includes such features as: A heavy steel chassis to eliminate EMI/RFI problems, a 12-slot passive backplane, a single-board CPU which protects system components from shock and vibration, and a protective door to cover the disk drive opening. Additional protective features include a shock-isolated mounting panel for a 3.5" hard drive, an industrial-quality power supply to provide line filtering with surge suppression, and dual fans to pull air through a modacrylic filter.

#IPC 286-16 Industrial Rack-Mount 16 MHz 80286 Computer **$2695**
#IPC 386-25S Industrial Rack-Mount 25 MHz 80386sx Computer **$2995**
#IPC 386-33 Industrial Rack-Mount 33 MHz 80386 Computer **$3695**
#IPC 486-33 Industrial Rack-Mount 33 MHz 80486 Computer **$4495**

Merritt
COMPUTER PRODUCTS

Constantly swapping diskettes? You need Merritt's FASTRACK!



Constantly swapping disks? Losing diskettes under papers on your desk or in a drawer? Disorganized? You need FASTRACK, Merritt's highly efficient diskette organizer.

FASTRACK attaches to your monitor or CPU with a clever, interlocking clip, making each modular unit moveable for desktop use.

Now you can have fingertip access to all those frequently used diskettes. FASTRACK's unique design allows modules to be "chained" together to extend capacity and convenience.

A very handy organizer, a welcome gift.

FASTRACK™

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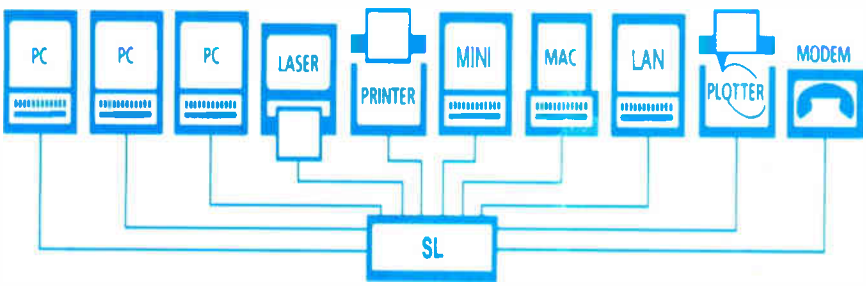

Model	Ports	PCs/ Printers	Memory Available	Priced From
SL	6 Ser/4Par	Any Combination	256KB-4MB	$495
SLP	8 Par/2 Ser	Any Combination	256KB-4MB	$495
HXS	4 Serial	Any Combination	256KB-16MB	$295
HXM	2 Ser/ 2 Par	Any Combination	256KB-16MB	$295
HWP	5 Parallel	3/2, 4/1	256KB-16MB	$295
HXP	4 Parallel	2/2, 3/1	256KB-16MB	$245
HCP	2 Parallel	1/1	256KB-16MB	$225
AS31	4 Parallel	3/1	None	$175
AS41	5 Parallel	4/1	None	$195
AS81S	9 Ser/ 1 Par	8/1	None	$79

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- Use "Workstation" Quality (and Performance) Peripherals
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MB	INTL	EXTL
52	$229	$299
105	339	429
120	449	539
240	699	789

SyQuest

Model		Bare
SQ-555		$399
SQ-5110		609
Dual	(ext. 44)	899
Dual	(ext. 88)	1449

2.6 GB DAT

APSArchive 2.6 GB Compression DAT	$1899
APSArchive Desktop and Portable Units	1499
TEAC 155 Above include Sytos Plus	599
WangDAT	1799

Maxtor

MB	Intl	Extl
120	$359	$439
213	579	679
340	999	1099
535	1549	1649
760	1649	1799

Micronics

Motherboards		
386SX	ISA 25	$259
386DX	ISA 25	419
386DX	ISA/33/Cache	569
486DX	ISA/33/Cache	999
486DX	EISA/33/Cache	1549

Toshiba

CD ROM	
3301B	$579

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- **Mounting Hardware & Cables Included** • All Hard Drives include rails, extenders and data cables required for standard operation. Board products are populated but without RAM.
- **Toll-Free Technical Support** • Toll-Free Technical Support, 9am to 7pm Monday thru Friday, Central Standard Time. As often or for as long as you need.
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- Optional 80387SX math co-processor
- 2MB memory on board
- 1.44MB 3.5" and 1.2MB 5.25" floppy drive
- 40MB 3.5" IDE hard drive
- 2 serial, 1 parallel, 1 game ports
- 512KB VGA controller on-board, expandable to 1MB, resolution 1024 x 768
- Super VGA monitor, 1024 x 768, dot pitch .28
- 101-key enhanced keyboard
- MS DOS 5.0
- One year on-site warranty

80386SX-16 $965

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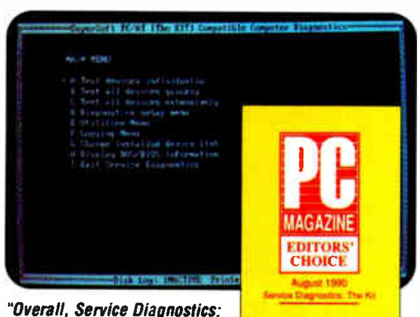

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T3100e	2MB Kit	119.00
T3200/SXC	2MB Kit	119.00
	4MB Kit	209.00
T3200	2MB Kit	119.00
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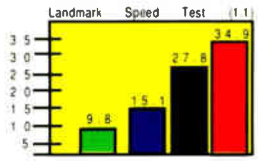

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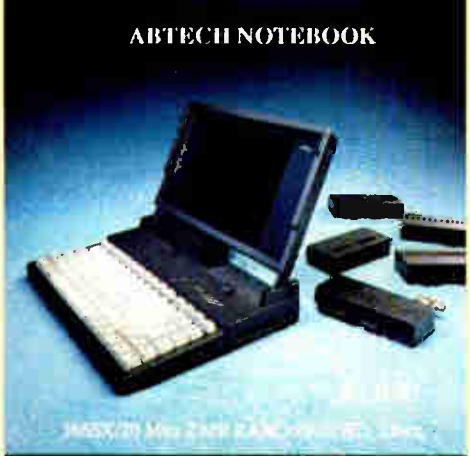

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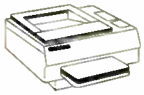

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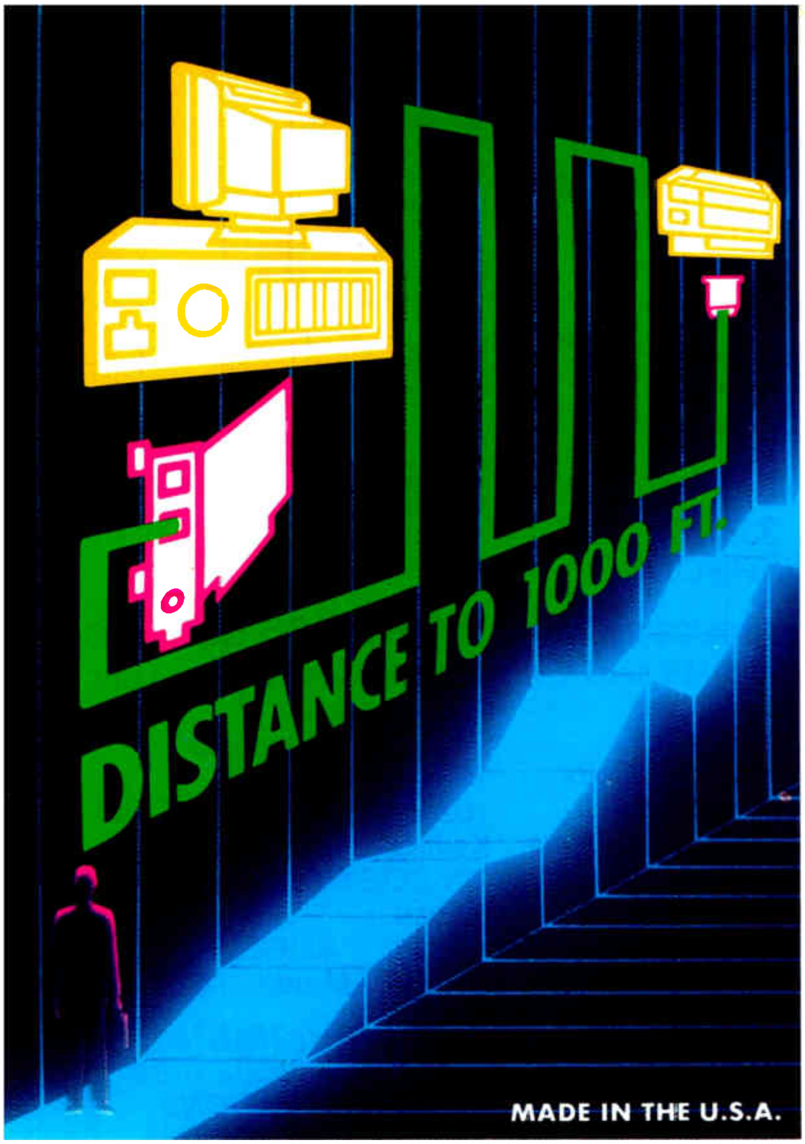

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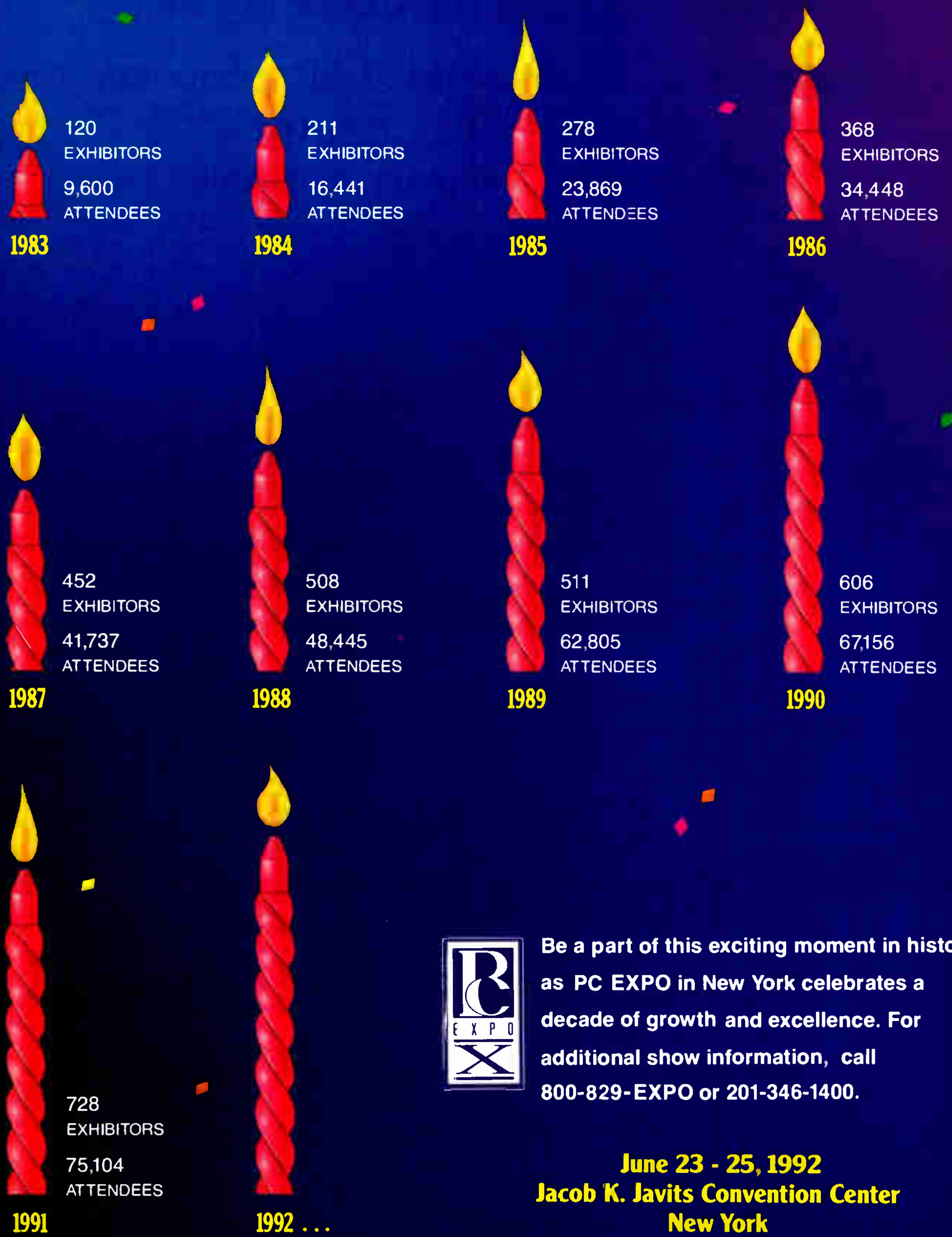

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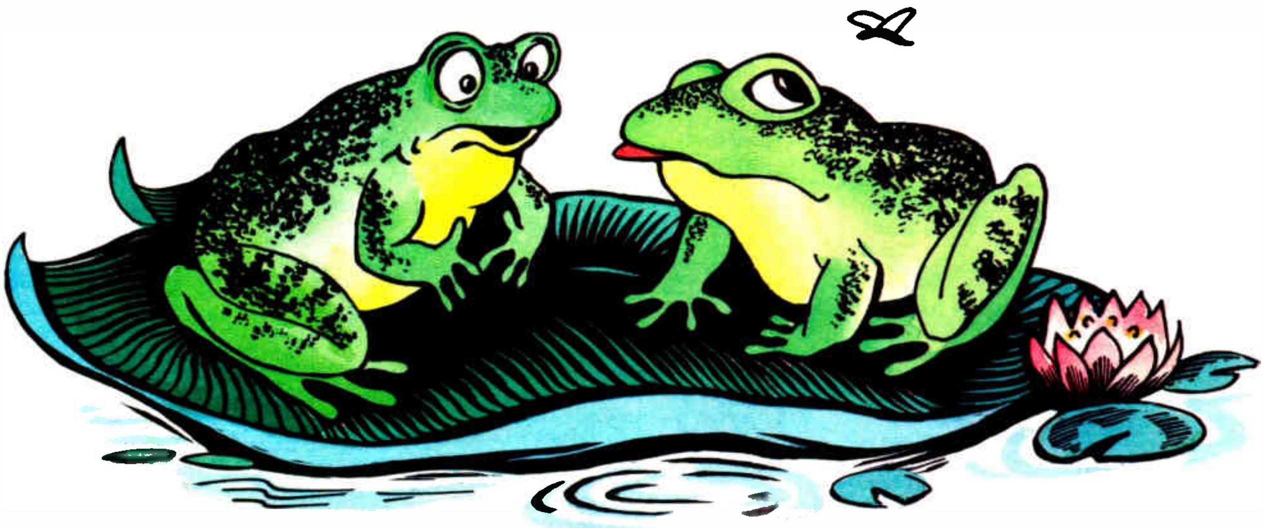

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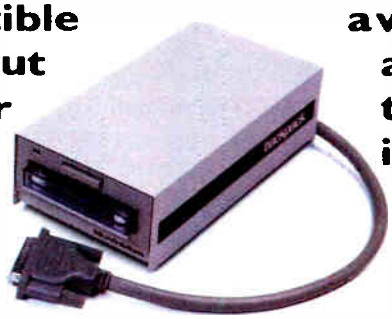

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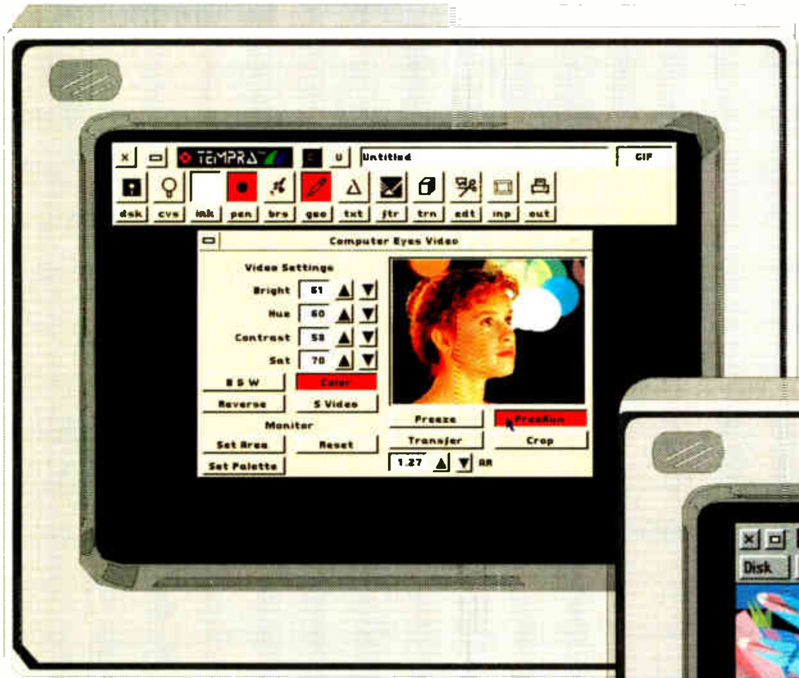

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Drawing Styles							
Arc	**16**	N/A	4	N/A	N/A	N/A	N/A
Circle	**12**	4	8	3	N/A	N/A	4
Curve (Parabola)	**8**	N/A	1	N/A	N/A	N/A	N/A
Ellipse	**8**	4	8	3	N/A	8	4
Freehand	**3**	3	4	2	2	4	3
Irregular Polygon	**2**	N/A	2	3	N/A	N/A	8
Line	**7**	7	6	2	4	8	6
Parallelogram	**4**	N/A	N/A	N/A	N/A	N/A	N/A
Rectangle	**12**	4	8	3	N/A	8	4
Regular Polygon	**24**	N/A	N/A	N/A	N/A	N/A	N/A
Spline (Bezier)	**2**	3	3	N/A	N/A	N/A	3
Square	**12**	4	8	3	N/A	N/A	4
Load/Display Times							
42K PCX	**:03**	:39	:11	:36	:05	:13	:05
330K TIFF	**:04**	:18	:14	:47	:05	:17	:06
289K Uncomp. TGA	**:03**	N/A	N/A	:45	:05	:16	:07
708K Comp. TGA	**:06**	N/A	N/A	N/A	N/A	N/A	:17
Image Formats							
!IM	✓	N/A	N/A	N/A	N/A	N/A	N/A
GIF	✓	N/A	N/A	✓	✓	✓	✓
PCX	✓	✓	✓	✓	✓	✓	✓
PTN	✓	N/A	N/A	N/A	N/A	N/A	N/A
TGA	✓	N/A	N/A	uncompressed	uncompressed	✓	✓
TIF	✓	✓	✓	✓	✓	✓	✓
WIN	✓	N/A	N/A	N/A	N/A	N/A	N/A
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Sierra HiColor VGA	✓	✓	✓	✓	✓	✓	✓
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All tests were performed on an Orchid Technology Privilege 386-33 with 8MB RAM and a Conner 200MB HDD. Windows apllications were tested in 386 enhanced mode with no other tasks running. TEMPRA is a trademark of Mathematica, Inc. All other products are trademarks of their respective owners. TEMPRA speeds clocked before turbo charger feature. Copyright 1991 by Gary A. Klein. All Rights Reserved.

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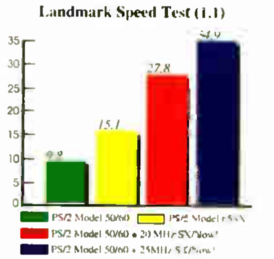

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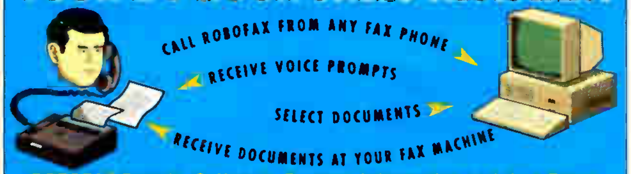

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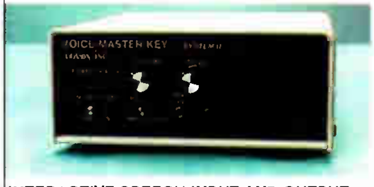

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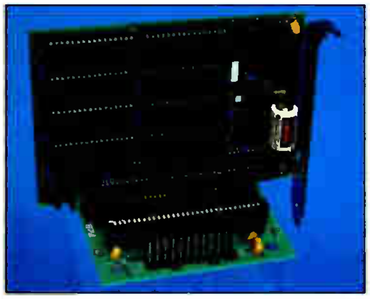

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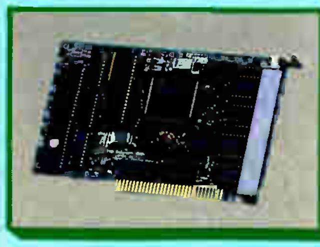

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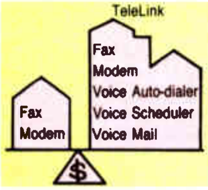

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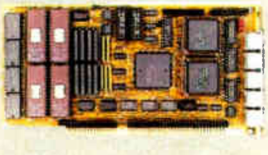

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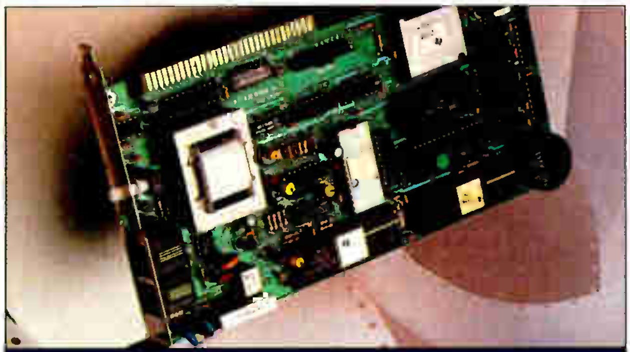

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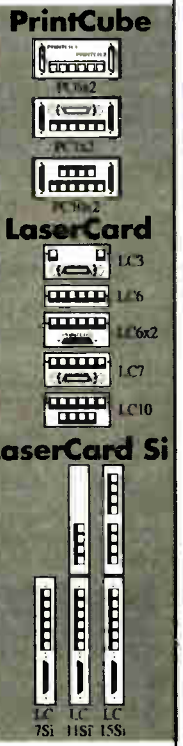

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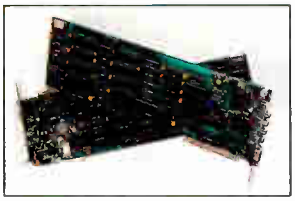

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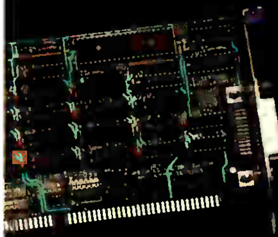

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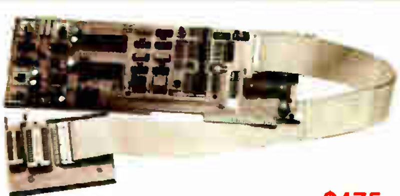

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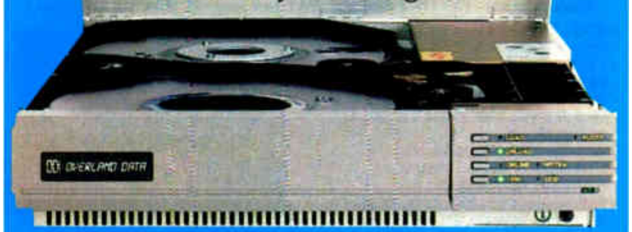

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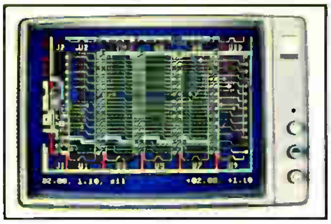

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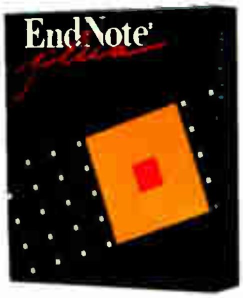

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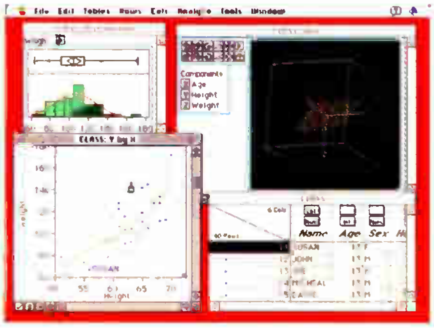

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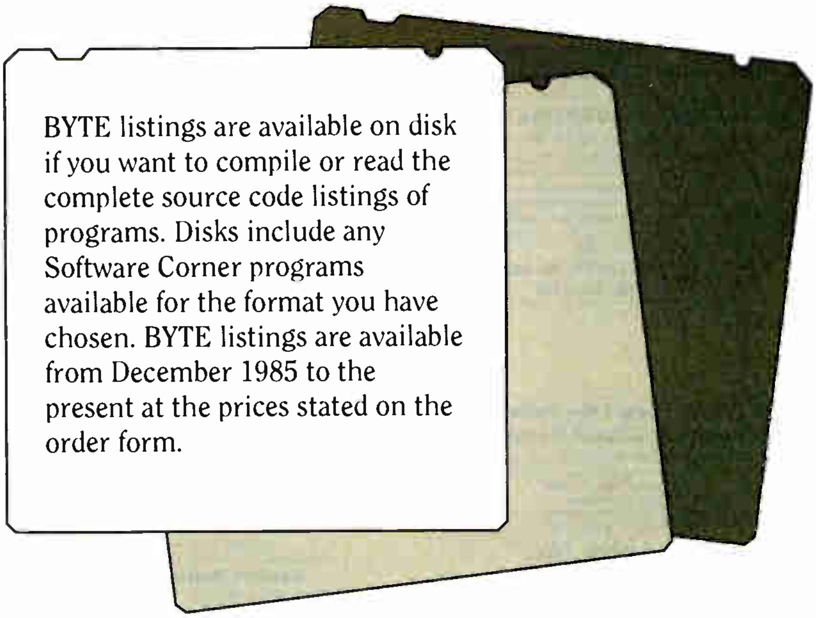

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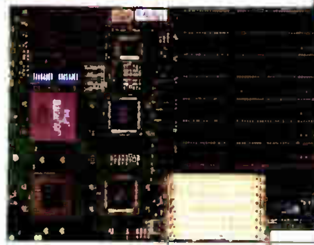

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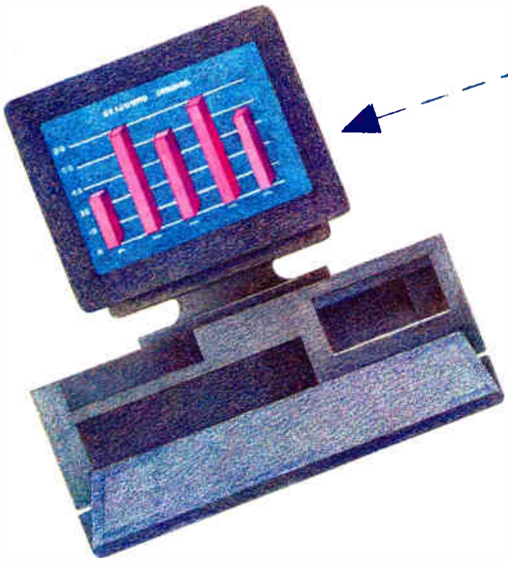

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PRINT QUEUE

HUGH KENNER

The Methods of Madness

Game theory, nuclear weapons, and real life

Chess, John von Neumann affirmed, is not a game. No, "Chess is a well-defined form of computation. You may not be able to work out the answers, but in theory there must be a solution, a right procedure for any position." The same is true of tic-tac-toe, where it's easy to show, by exhausting the possibilities, that with error-free play you can always force a draw. The possible moves in chess are likewise finite; working them out, though tedious, would be simple, were the universe so constructed as to afford enough time. So the ideal chess encounter is predetermined, although after several centuries we're still unsure whether its end would be victory for White or a draw. For no such encounter has ever been played clear through. Every match on record has ended prematurely because someone blundered; hindsight can always show what he or she should have done.

But real games, unlike chess, resemble real life. "Real life consists of bluffing, of little tactics of deception, of asking yourself what is the other man going to think I mean to do."

Even so, assuming ideally rational players—a large assumption—game theory remains a branch of mathematics, if not of computation. In William Poundstone's paraphrase, a von Neumann "game" is "a conflict situation where one must make a choice knowing that others are making choices too, and the outcome of the conflict will be determined in some prescribed way by all the choices made." (Poker, a game, makes you weigh what others may be guessing you may be thinking. Chess, a computation, makes all choices sequential, Black deciding a move *after* seeing what White did. It's a subtle but decisive distinction.)

In their 1944 *Theory of Games and Economic Behavior*, von Neumann and Oskar Morgenstern were able to show that in any two-player game so defined, and *provided the players' interests are completely opposed*, there is always at each step a rational course of action, leaving each player satisfied in hindsight that he or she couldn't have played better.

Poundstone's *Prisoner's Dilemma* weaves together a sketchy but arresting life of John von Neumann, an unfolding exposition of game theory, inside looks at the Rand Corp., vignettes of the cold war, and more, the better to show us what grip the theory may offer on what we've all been through in the past 50-odd years. Page by page, it's clear and vivid. And what emerges with great clarity is this: The famous von Neumann-Morgenstern theory is a special case. For in the real world, players' interests are seldom opposed with mathematical decisiveness. (We didn't want to lose the cold war. But we also didn't want the likely cost of winning; for instance, having New York zapped. Nor did we savor gloating over an atomized foe; think of the moral and economic cost of just picking up the pieces.)

Cheating, which undermines the common good, can also offer the richest payoff. That's the heart of much poker strategy (which reduces to judicious bluffing, if only we had a way to define *judicious*). It's also why real estate law provides for something called escrow.

Put poker principles into a different scenario, and you have Prisoner's Dilemma. Three of us are in jail for a year, on some minor conviction. But the lawpeople feel sure we conspired at something major. So they offer us each a deal: Testify, and go free; leave your buddies to stew for *five* years. Or stay mum, and just finish your one-year sentence. Now: What's my best strategy?

Testifying carries the best payoff, but only if I'm the first to choose it. Staying mum is next best, but only if both buddies stay mum, too. And I'm worst off staying loyally mum while a buddy squeals. So everything depends on my guessing right about the guesses of two other people, who are meanwhile frantically guessing about me. And the poker analogy starts to break down, because this is a one-time situation. With a weak poker hand, you can bluff at intervals and perhaps come out ahead statistically.

A preemptive strike at the U.S.S.R., which masters of abstraction as different in temperament as John von Neumann and Bertrand Russell were urging in the late 1940s, would have been a one-time event likewise. Doubtless, men in the Kremlin were urging a preemptive strike against the U.S. It's not surprising that Prisoner's Dilemma theory was pioneered at Rand, where an early project was selecting choice Soviet targets, or that in 1971, Rand's Martin Shubik published a fiendish complication, the Dollar Auction.

The bidding starts at a cent, and a dollar bill goes to the highest bidder. But the *second*-highest bidder must pay the amount of his or her bid and receive nothing. So once bidding gets up to $1, someone has a stake of 99 cents to protect, and by offering $1.01, he or she may confine the loss to just 1/99 of that! But then someone else must lose a whole dollar or else up the ante to $1.02. And how long may such craziness go on? On some trials, as high as four or five times the prize, the last bidder paying $5 (a net loss of $4) to leave his or her rival losing $4.99. Poundstone adduces a Saddam Hussein speech of January 1991 ("Our losses are now so great that we must fight to the end."). Is this madness? Try a Dollar Auction, and watch the madness spread through a phalanx of Ph.D.'s. ■

Prisoner's Dilemma, William Poundstone, Doubleday, 1991, $22, 290 pp., ISBN 0-385-41567-2.

Hugh Kenner is Franklin and Callaway Professor of English at the University of Georgia. He writes for publications ranging from the New York Times *to* Art & Antiques. *His recent books include* Mazes *and* Historical Fictions. *You can contact him on BIX as "hkenner."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

STOP BIT

STEVE MOORE

DIGITAL DECEPTIONS

The use of real-time video manipulation could redefine reality

Imagine for a moment that we are in the midst of the 1996 presidential campaign. A candidate is making a televised speech. A technologist hired by the opposing campaign is grabbing the video signal and modifying it in real time, making the candidate look pale, nervous, unphotogenic...unelectable. Perhaps even the very words the candidate utters are being subtly altered, along with the facial movements that correspond with them.

No way, you say? Think again. The technology exists *today* to intercept an analog video signal and its sound track, digitize them, edit them in real time, and send them back into the analog world with so little delay that no one is the wiser. Real-time, on-line image and soundtrack crunching is now possible.

Seeing is no longer believing, and no videotape or photograph can be considered evidence of the truth. The editors who are the gatekeepers of the world's print and electronic media must attain new levels of vigilance to protect their audiences from digital deceptions. Beyond safeguarding the truth, society must deal with privacy issues when the elements of an individual's personality—his or her image and voice—become digital commodities.

Modifications to chemical-based film have usually been detectable, but modifications to digital images are virtually impossible to detect. What tools will the gatekeeper have to detect a deception when someone wants to subject a 1996 presidential candidate to embarrassment?

Digital deceptions aren't limited to the subtleties of real-time video manipulation. Why not apply the disciplines of synthetic acting and off-line video editing to come up with a videotape that shows a certain male candidate inviting a known call girl into his limousine? From there, it's a simple step to send damning videotapes to the print and broadcast media—anonymously, of course.

Synthetic actors will be a reality by 1996. An early demonstration came at the 1988 ACM SIGGRAPH conference, when two actors who never appeared in the same film—Humphrey Bogart and Marilyn Monroe—appeared together in Toronto, where neither had ever shot a scene. Their faces and voices left no doubt as to their identities. Yes, the polygons on the surfaces of their computer-modeled faces gave them away. But it's just a matter of time before such artifacts are eliminated and photo-realistic synthetic acting becomes commonplace.

Sound manipulation is here now. Technicians can digitally sample and reproduce the sound of a musician's instrument or a singer's voice at will. Just ask Michael Jackson about that annoying commercial that used his voice without his permission.

The technology also has its upside: Video editing and synthetic acting may revolutionize Hollywood by eliminating the need to bring back actors, extras, and camera crews to reshoot movie scenes. Just tell the video computer to capture the actors' images and voices and then manipulate them according to software scripts. This can go on for as long as the director wants to sit in front of a keyboard and screen.

And here's a real-time video-editing application in the medical realm. According to Steve Elliott of GW Hannaway and Associates, a computer graphics lab in Boulder, Colorado, everyone has a "hole" in their vision at the point where the optic nerve attaches to the eye. The eyes' smart input devices and the brain's computing power automatically mask this naturally occurring blank spot. But some people suffering from retinal failure have an additional visual blank spot that the brain can't deal with.

What to do? Just have the patient wear stereo video glasses that display a real-time distortion pattern that fools the eye and brain into thinking that this extra blank spot is a second optic nerve hole. The brain says, "OK, I've seen this type of pattern before," and deals with it.

Are real-time image modification, synthetic acting, and other digital video technologies a blessing or a curse? That depends on the answers to questions such as these: Who will police the use of a person's image and voice for purposes that person doesn't condone? What laws will cover such abuses? Call it *virtual reality*, call it *data slurping*, or call it *morphing*, the implication is the same: Elvis may yet sing and act again.

Remember, it was only an aural virtual reality that caused a panic in the U.S. in 1938, when Orson Welles presented his famous radio broadcast of H. G. Wells's *The War of the Worlds*. Imagine the impact today if TV viewers saw a spacecraft land at the White House right in front of the president.

Finally, who will train the government security forces of the future to contravene the virtual video terrorists of the future? It's worth thinking about. ■

Steve Moore is a freelance author in Wellesley, Massachusetts. His ideas form the basis for his recently completed but not-yet-published novel The Virtual Campaign. *You can reach him on BIX c/o "editors."*

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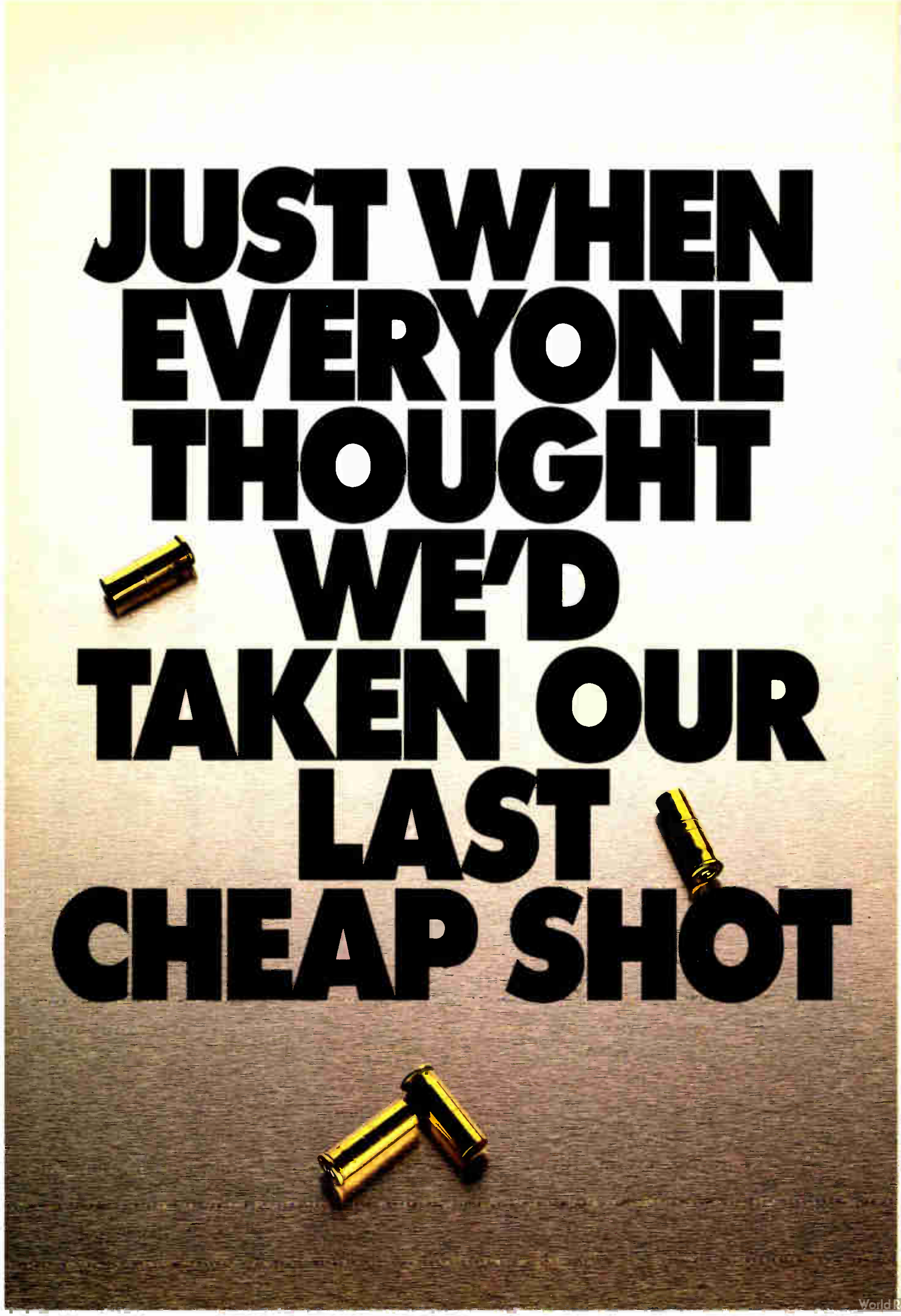

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