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BYTE

OCTOBER 1989
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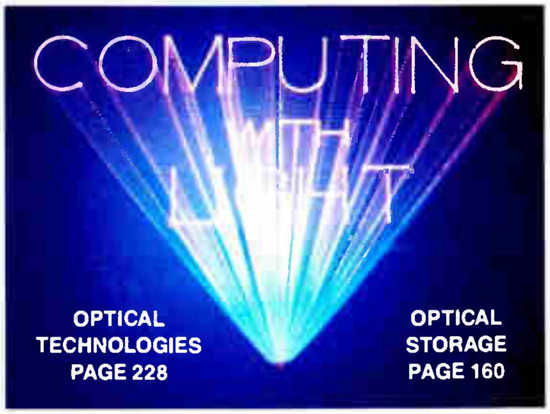

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Quattro 2

Bill Gates on BASIC

Parallel Processing with Macs

Understanding Disk Caching

Inside AppleTalk and NetBIOS

6 Short Takes

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New IBM and Mitac SX Systems

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Two Portable Printers

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- Socket for Intel 80287 math coprocessor.
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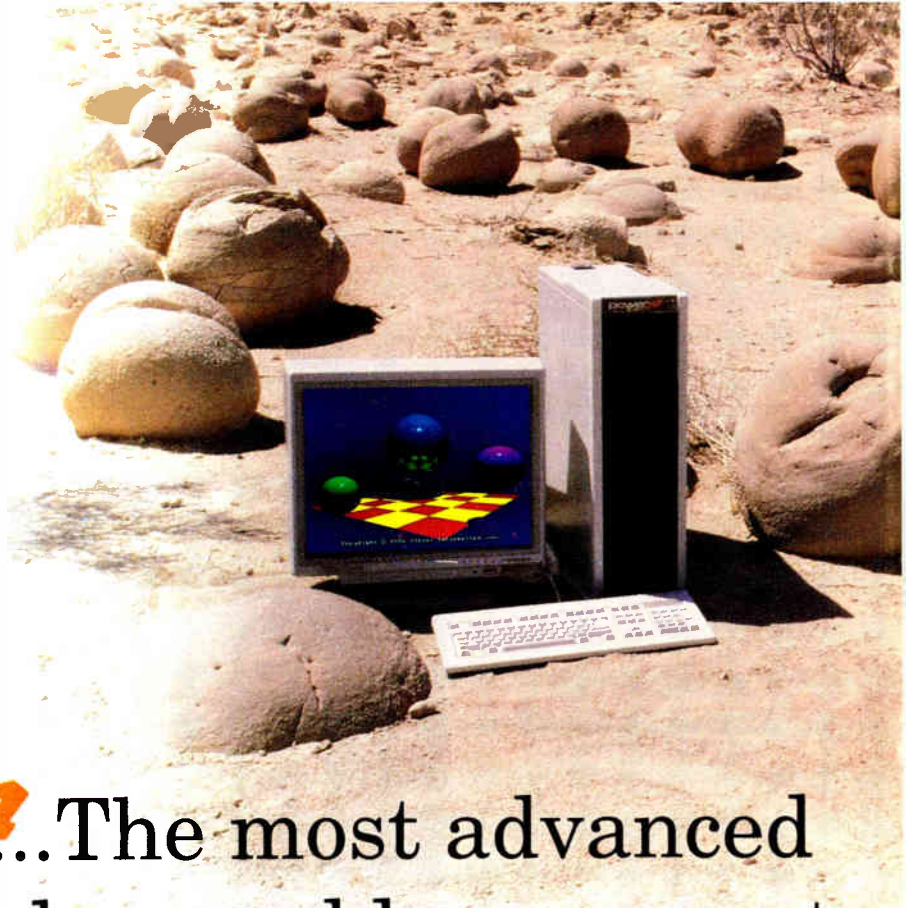

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At ALR, we will never rest on our laurels. We strive to be the best, as proven by our past achievements. Now with the introduction of the new ALR PowerCache 4™, we've designed a system that is far beyond comparison. Again, we have taken PC-microprocessing power a step further by designing a unique proprietary PowerCache 4 cache controller using ALR's custom ASIC chips which deliver the fastest processing speed ever.

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PC MAGAZINE, *January 1989,*
"In a field of powerhouse machines there can only be one winner, and ALR's FlexCache is it."

INFO WORLD, *July 1989,*
"ALR Systems Unleash 486 Power. The PowerCache 4 shines in the CPU-specific portion of the InfoWorld Automated Benchmark Test, gaining a score of 16.3."

PC WEEK, *July 1989,*
"Based on a series of benchmarks run last week on Advanced Logic Research, Inc.'s prototype 486 desktop system, ALR will enter the 486 market with a bang."

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CPU	25 MHz i486	25 MHz i486	25 MHz i486
Bus	MCA	MCA	MCA
External Cache	128 KB cache Read and Write-Back	128 KB cache Read and Write-Back	None
Video Opt. on board	640x480 1024x768	640x480 1024x768	640x480 None
I/O Slots	6 expansion slots	6 expansion slots	3 expansion slots
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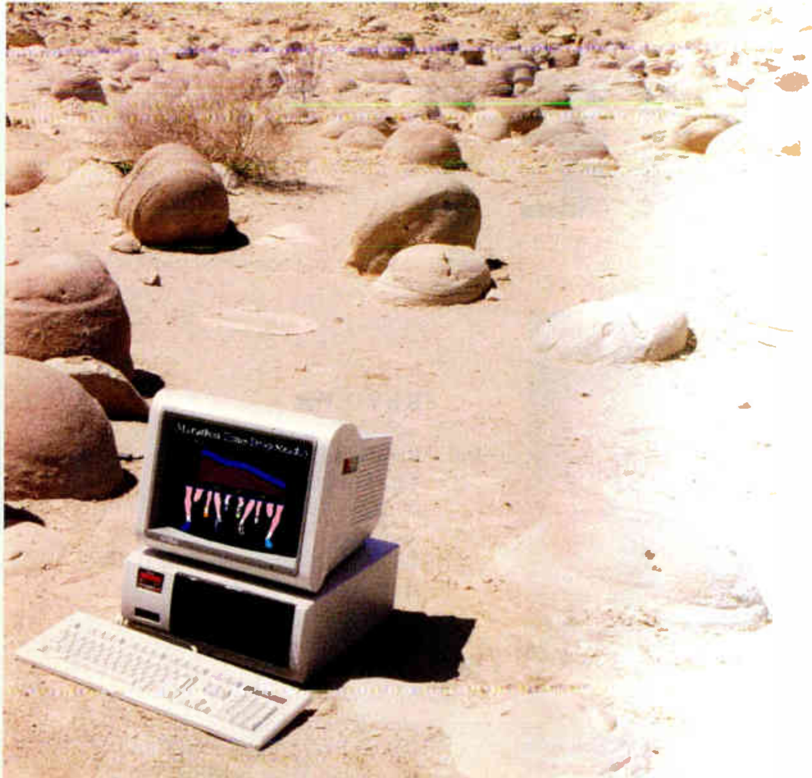
Disk Capacity	130 MB-260 MB	150 MB-650 MB	110 MB
Price	$9,990	Starting at $11,490	$12,990



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BYTE

OCTOBER 1989 VOL. 14/NO. 10

PRODUCTS IN PERSPECTIVE

49 What's New

81 Short Takes

PageMaker for OS/2 Presentation Manager, *Aldus puts desktop publishing in the fast lane*
Think C 4.0, *a major upgrade from Symantec*
DeskWriter, *Hewlett-Packard's ink-jet printer for the Mac*
HyperAccess/5, *Hilgraeve adds many new features*
DOS Mounter, *a utility from Dayna to use with Apple's FDHD*
hyperStore-816 *and* **SmartCache PM3011**, *caching disk controllers from Perceptive Solutions and Distributed Processing Technology*

FIRST IMPRESSIONS

111 VROOMM Goes the Spreadsheet
by Rich Malloy
Borland's new Quattro combines the advantages of Excel with Lotus 1-2-3 compatibility.

COVER STORY

The Portable and the Powerful
by Tom Thompson and Frank Hayes
page 98

Apple's Portable Mac finally arrives, accompanied by the impressive Mac IIci.

REVIEWS

160 Product Focus: The Optical Option
by Steve Apiki and Howard Eglowstein
WORM and erasable optical disk systems offer practical, large-scale storage.

181 MCA Meets SX
by Mark L. Van Name and Bill Catchings
IBM's PS/2 Model 55 SX and American Mitac's MPS2386 combine MCA with the 80386SX.

187 Color Printer Quells Price-Tag Blues
by Tom Thompson
ColorQuick offers Mac users a slow but effective alternative to pricey thermal printers.

191 Speed Separates Two Portable Printers
by Wayne Rash Jr.
Kodak and Toshiba take different routes to design printers for the road.

EXPERT ADVICE

115 Computing at Chaos Manor: Disasters and Diversions
by Jerry Pournelle
Jerry tries to revive a damaged floppy disk and glories in using new CD-ROM products.

131 The Unix /bin: The Root to Happiness
by David Fiedler
Working with Unix has its privileges—literally.

143 OS/2 Notebook: A Compendium of OS/2 Applications
by Mark J. Minasi
A new OS/2 application guide lists hundreds of programs.

144E Macinations: Crimes of the Heart?
by Don Crabb
Don delineates his Macintosh wish list.

151 Down to Business: IBM's Vision for Your Office
by Wayne Rash Jr.
OfficeVision brings IBM's grand plan into view.

155 NetWorks: Breaking Down the Barriers
by Mark L. Van Name and Bill Catchings
A look at the issues you'll face if you try to integrate PCs and Macs on a LAN.

REGIONAL SECTION
begins after page 80

195 **Four Debuggers in One**
by Martin Heller
The MultiScope OS/2 debugger from Logitech challenges Microsoft's CodeView.

201 **X Window System on the March**
by Tom Yager
A look at 386/ix X11, a new 80386 X Window system from Interactive Systems.

211 **Visually Map Your Data**
by Stan Miastkowski
Mapping Information Systems' MapInfo puts your dBASE III data on the map—literally.

217 **How Super Is SuperCard?**
by Richard D. Lasky
Silicon Beach's improvement on HyperCard's features may have been costly in performance.

IN DEPTH

228 **Introduction: Optical Technologies**

231 **Computing With Light**
by H. John Caulfield
Optical computers combine the best of the electronic and optical worlds.

239 **The Nitty Gritty Optical Band**
Optical developments occur in the "nitty gritty" aspects of packaging, interconnections, ICs, and signaling:

240 **Levels of Light**
by Joseph W. Goodman
Optical interconnections are one route to high-speed computing.

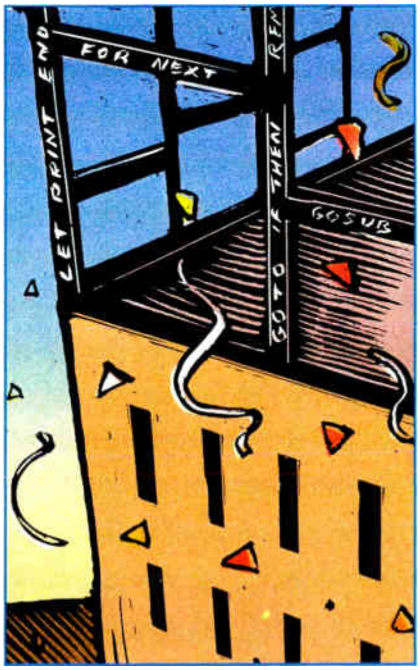
244 **Joining Forces**
by Donald J. Channin
Optoelectronics combines optics and electronics on a single chip.

249 **Reflected Light**
by Gary T. Forrest
Laser technology has an impact on everything from laser printers to optical disks.

259 **Gigabytes On-Line**
by James J. Burke and Bob Ryan
Erasable optical disk drives will change your notions of mass storage.

266 **Read/Write Optical Subsystems**
A guide to optical drive systems that let you store your own data.

FEATURES



268 **The 25th Birthday of BASIC**
by Bill Gates
Microsoft's chairman and coauthor of Microsoft BASIC tells where BASIC has been and where it's going.

279 **Occam II**
by Dick Pountain
The Occam II language is designed for parallel processing.

287 **Hands-On Parallel Processing**
by Geoffrey C. Fox, Alex W. Ho, Paul Messina, and Terry Cole
How to assemble a functional hypercube using Macs and AppleTalk.

HANDS ON

297 **Under the Hood: Disk Caching**
by L. Brett Glass
How to evaluate different disk-caching schemes.

303 **Some Assembly Required: Two Tin Cans and Some String, Part 1**
by Rick Grehan
The first of a two-part series comparing AppleTalk and NetBIOS.

DEPARTMENTS

8 Editorial: Hip-Deep and Rising
17 Microbytes
32 Letters and Ask BYTE
48C Chaos Manor Mail
351 Coming Up in BYTE
360 Print Queue
364 Stop Bit

READER SERVICE

350 Editorial Index by Company
352 Alphabetical Index to Advertisers
354 Index to Advertisers by Product Category
Inquiry Reply Cards: after **356**

PROGRAM LISTINGS

From BIX: See **358**
From BYTEnet: call (617) 861-9764
On disk: See card after **248**

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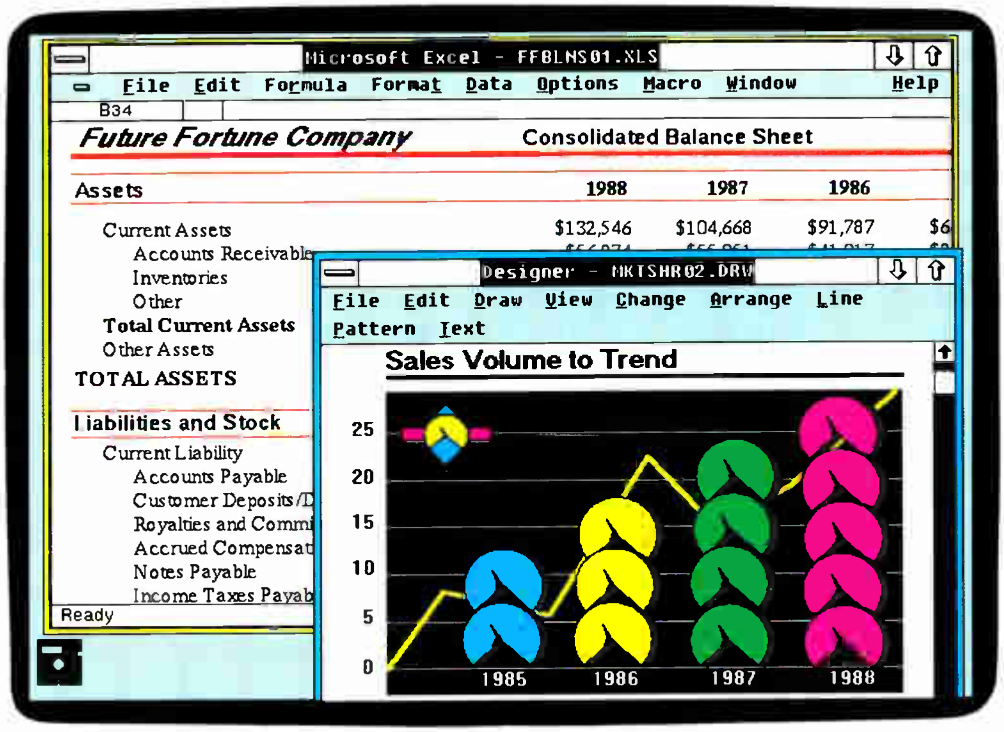

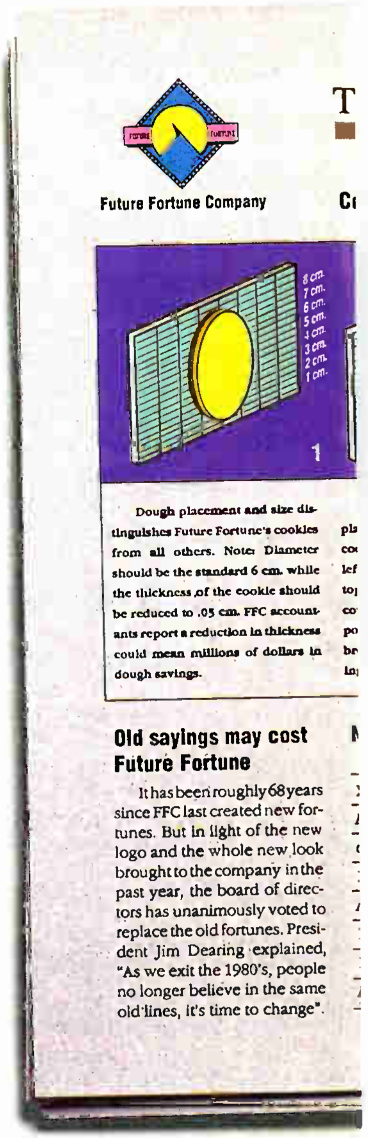

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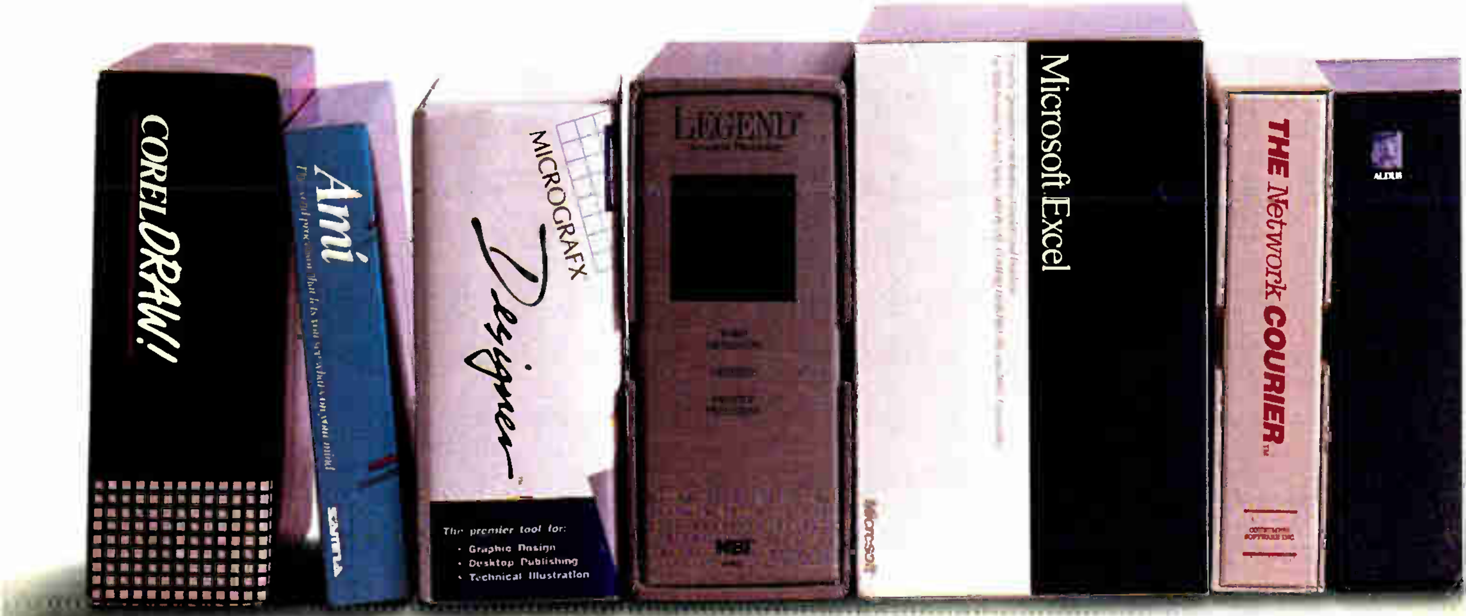

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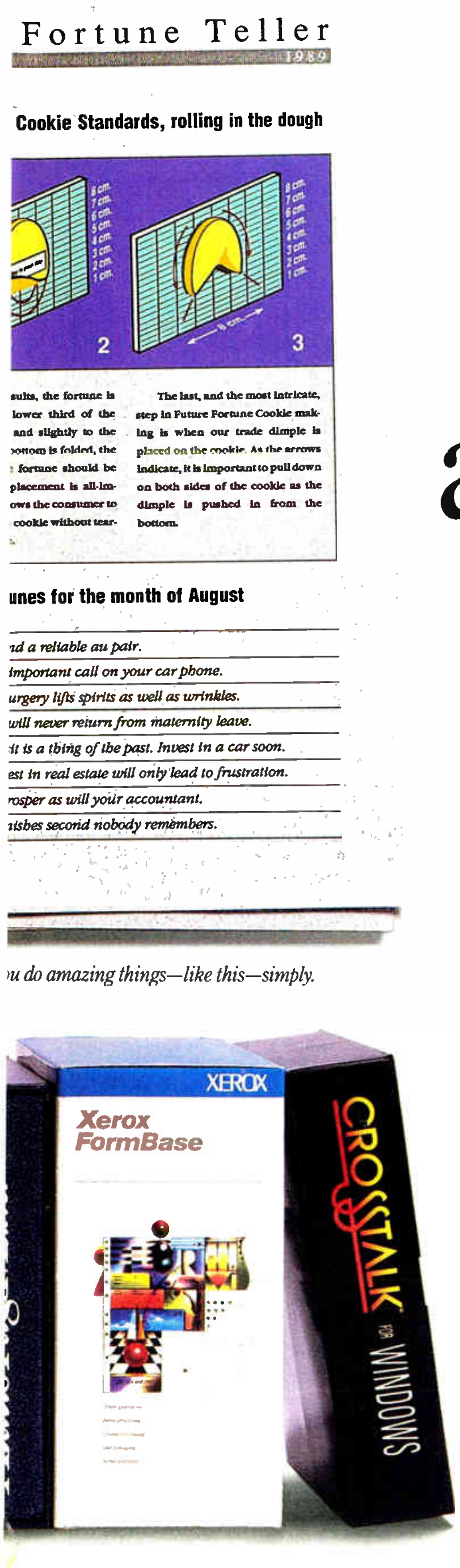

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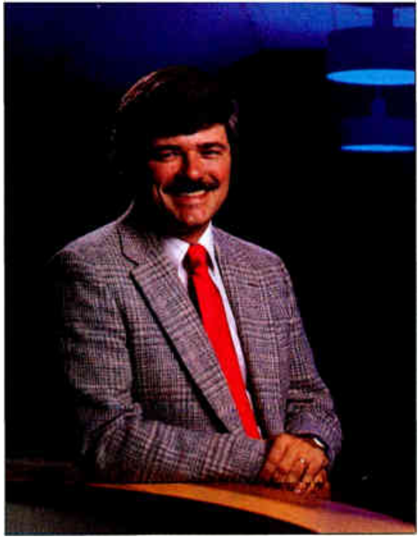

HIP-DEEP AND RISING

Smoke, mirrors, and misinformation can make your computing decisions needlessly complex

Some decisions are easy. Some are inherently difficult. And far too many are made unnecessarily difficult by smoke, bluster, and misinformation.

It's a problem that knows no boundaries of brand, operating system, or architecture, but for simplicity's sake, consider just the decisions involved when upgrading 80286- and 80386-based machines. I'll look at the 80386-based machines first.

If you bought a 16-MHz 80386-based machine a few years ago, you're probably now wondering about upgrading to 20, 25, or 33 MHz. If your current machine is working fine, it's merely a matter of checking out the specifications, benchmark results, and prices of the newer machines to see how many bucks the extra bang is going to cost you. Either the increase in speed (and, one assumes, productivity) is worth the expense, or it isn't. It's a relatively simple equation, with all factors known or knowable. Piece of cake.

Yes, certain complications can muddy the waters. For example, some early 80386 boxes accommodate only a relatively small amount of RAM on the motherboard and lack 32-bit memory-card slots. If you want to run memory-hungry software on such a machine, you'll have to use a regular AT-class memory card and suffer the delays imposed by the 16-bit bottleneck. This factor alone may justify an upgrade, even if there's nothing else "wrong" with your current setup.

A few unlucky souls face some really oddball complications. For example, some early 80386 chips were buggy. Once Intel knew there was a problem, it (laudably) instituted a liberal exchange policy to get the bad chips out of circulation. But despite Intel's efforts, there's little doubt that some manufacturers—especially the low-end cloners—shipped some systems with bad chips.

The total number of bad chips now in daily use is probably small, but for those who have those early chips, it could be bad news. One of the bugs, for instance, causes incorrect 32-bit multiplies, which may be no big deal under vanilla DOS but can be a real headache with 32-bit software.

Factoring this kind of problem into an upgrade decision involves a little spelunking: You'd need to physically examine or test a suspect chip. (Intel stamped two Greek sigmas on chips that were known to be good.) Also, there's public domain software that performs a quick-and-dirty 32-bit multiply and then checks the answer for accuracy. Such software is available on BIX in the IBM Exchange: Search for "bug" or "multiply" to find it.

So far, so good. Even with some oddball complications thrown in, you can find good answers to most upgrade questions. But artificial, unnecessary complications, like the spread of bad information, can make upgrade decisions very hard indeed.

Take the 80286 versus 80386SX question, for example. It shouldn't be at all difficult to sort out. BYTE readers got the full story last March, when our 80286 versus 80386SX cover story "Battle of the Chips" detailed the similarities and differences between the chips. Readers could fairly easily determine when it made sense to stay with fast 80286-based machines, when it made sense to opt for an 80386SX, and when it made the most sense to go with a "real" 80386 (without the SX's 32-bit-to-16-bit bottleneck).

But there's still a ton of confusion among users at large. Some people still think you need an 80386 to run OS/2. (You don't. An 80386-specific version of OS/2 won't be available until next year.) Some think that an 80386SX is inherently faster than an 80286. (It's not. At any given clock speed, an 80286 will generally keep up with an 80386SX; and in a number of important areas, like task switching, the 80286 is substantially faster than the SX.) Some think an 80386SX will save them money. (Not really. Most SX machines cost hundreds of dollars more than just-as-fast 80286 boxes. And some low-end 80386 clones, with full 32-bit memory buses, actually cost less than some name-brand SX machines, with their 16-bit buses.)

The problem here isn't the SX—there are cases where the SX is indeed the best choice. And as prices for the SX continue to drop, it will become more attractive and more competitive.

The problem is that this is just one of a growing number of instances where misinformation makes a computer decision needlessly complex. The sources of misinformation abound—some innocent, and some deliberate. Compare BYTE's SX story to a recent cover story in another major computer magazine, whose purpose seems not to be helping readers match the right tool for the job, but pushing them toward buying powerful and expensive gear, regardless of whether it's overkill. Misleading ads are bad enough, but when supposedly objective publications start acting as shills, it's downright scary.

As consumers, we need to be exceptionally alert to the hidden agendas of our information sources. Caveat emptor was never sounder advice. Upgrade decisions are hard enough without getting distracted by bad recommendations, bad information, or plain old hype.

—Fred Langa
Editor in Chief
(BIX name "flanga")

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PC WEEK POLL: C COMPILERS

	Overall Weighted Score	Overall Reliability	Complete of Command Descript.	Overall Perform.	Complete & Organiz. Document.	Document Clarity	Compiling Process Efficiency	Product Support Quality	Value Relative To Cost	Product Support Access.
Turbo C 2.0 (Borland International)	81	87	79	84	77	78	86	72	70	93
C Optimizing Compiler 5.1 (Microsoft Corp.)	76	83	80	81	78	74	76	68	67	70
C++ 1.07 (Zortech Inc.)	66	68	64	71	63	63	69	60	58	76

"Microsoft was No. 1, but they have been unseated by Borland." PC Week, *May 8, 1989*

PC WEEK POLL: SOFTWARE DEBUGGERS

	Overall Weighted Score	Overall Reliability	Effective. Programmer Interface	Document. Clarity	Complete. Command Descript.	Complete. & Organize. Document	Overall Perform.	Integration Within Programming Environment	C Compiler Compatibility	Product Support Quality	Product Support Access	Value Relative To Cost
Turbo Debugger 1.0 (Borland International)	84	89	90	81	81	81	89	88	81	73	72	93
Codeview 2.2 (Microsoft Corp.)	73	80	71	72	74	74	74	74	78	67	64	72

"Borland's Debugger outshines Microsoft's Codeview." PC Week, *May 15, 1989*

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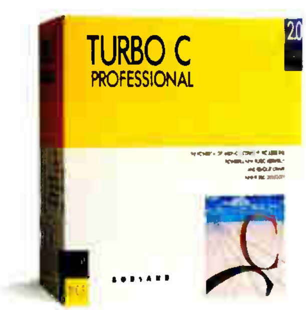

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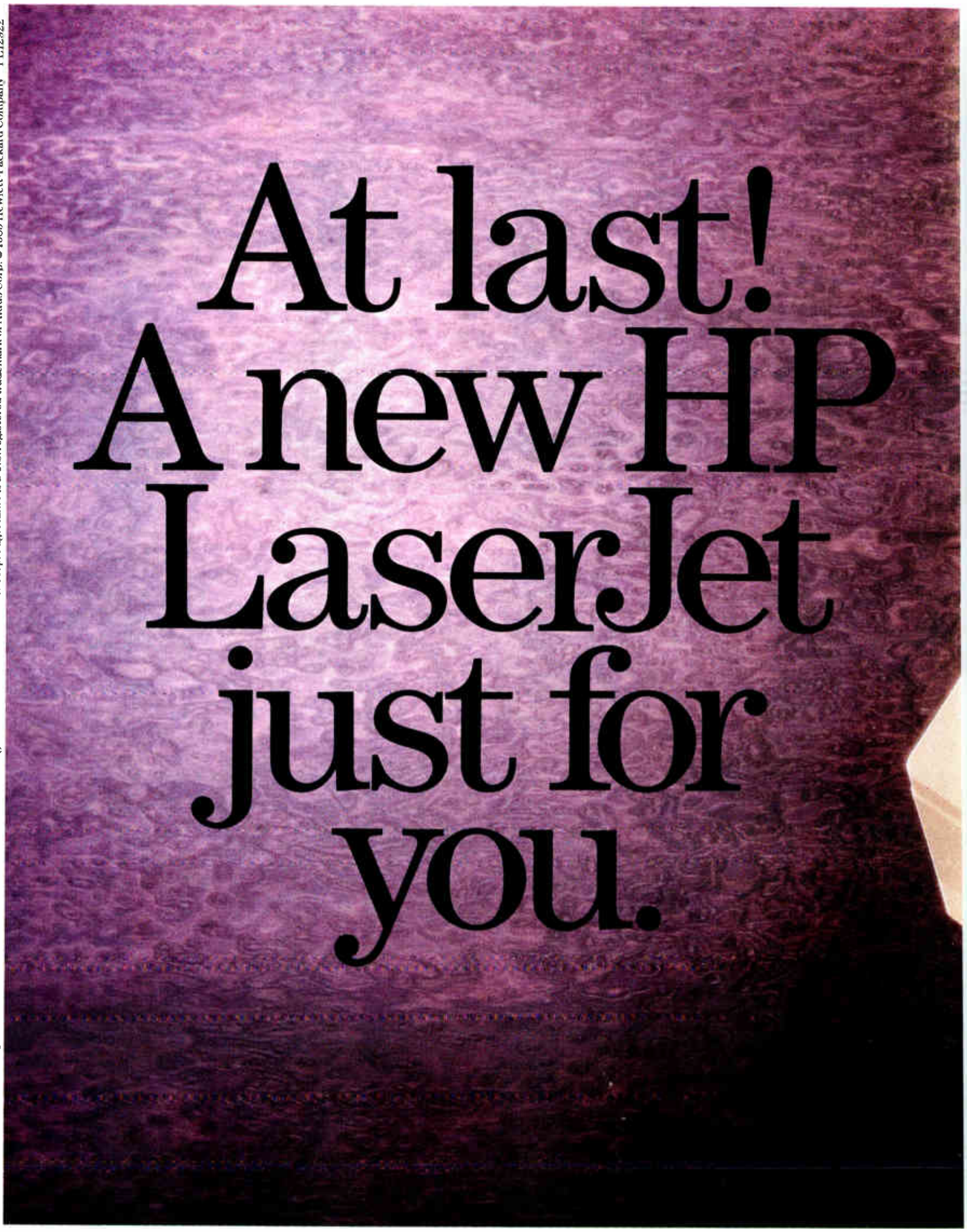

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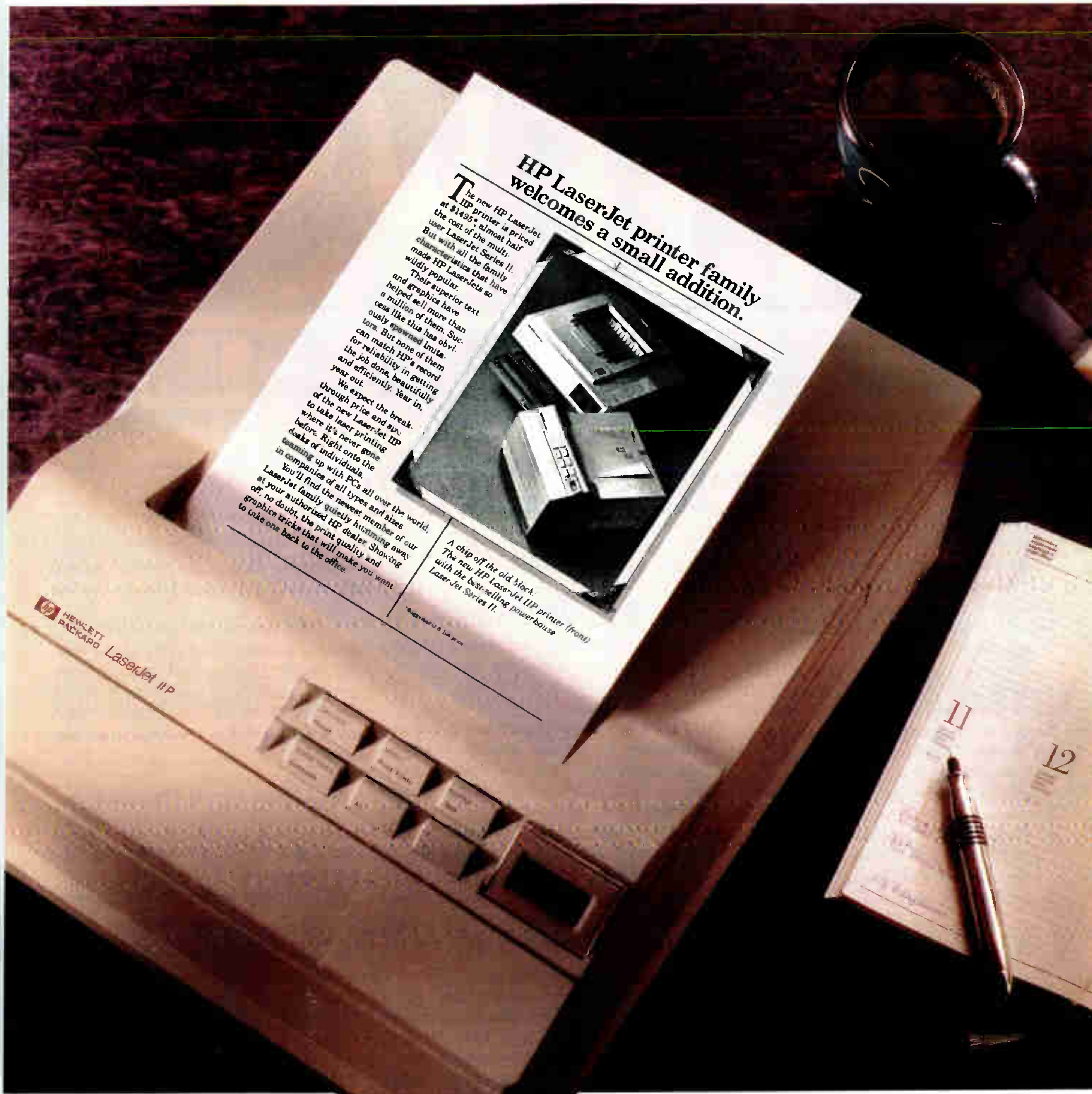

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World Radio History

Staff-written highlights of developments in technology and the microcomputer industry, compiled from Microbytes Daily and BYTEweek *reports*

Is Classroom Computing Making the Grade?

Are computers in schools helping children learn? As school districts across the nation become more pressed for money, educators are having to ask themselves if computers are worth the expense. Many of the 2000 computer coordinators, administrators, and teachers at the National Educational Computing Conference in Boston recently said that they came looking for justification for using high-cost technology. But judging by papers delivered and comments made at the NECC, final grades aren't in yet on the benefits of computers and computer courses in the classroom.

After *The National Assessment of Educational Progress* was published by the Educational Commission of States, painting a grim picture of U.S. schools, some educators proposed programming courses as a means to improve weak thinking skills. But while the number of schools teaching programming courses continues to increase, so does the number of studies failing to document significant improvements in students' thinking skills as a result of these courses.

Mark L. Walker and Sharon Carver of the University of Rochester say that schools justify every subject in the curriculum on the grounds of two educational goals: "transmission of substantive subject-matter knowledge and the enhancement of general problem-solving skills."

Walker and Carver studied and tested the effectiveness of a curriculum to foster planning skills. The students started their 18 months of Logo programming in the fifth grade, doing tasks that involved list processing and essay writing. The team studied the think-aloud protocols used by the students. Their study concluded that programming effectively enhanced general problem-solving skills when students already had "the relevant prerequisite knowledge in each of the domains" in which they expected students to apply the general skills. The students who lacked the prerequisite knowledge did not benefit from learning to program a computer, the study said.

Another study, by Yuen-Kuang Liao and George W. Bright of the University of Houston, presented in a paper entitled "Computer Programming and Problem-Solving Abilities," suggested that "the outcomes of learning a computer language go beyond the content of that specific computer language." Students are able to obtain some cognitive skills, such as reasoning, planning, and general problem solving "through computer programming activities," they wrote. However, Liao and Bright said they need to clarify the "exact nature of the problem-solving abilities most likely to be developed through programming." They question whether computer programming is as efficient at developing these problem-solving abilities as other possible instructional approaches.

Pocket Memory Cards: Companies Seek Standards for Tiny Storage Devices

Memory cards are an essential component in the new wave of notebook-size computers. Without such tiny storage devices—they're about the same dimensions as a credit card—manufacturers such as NEC, Agilis, and Poqet wouldn't have been able to fit their full-fledged computers into packages more portable than a six-pack of beer. These cards, made by NEC, Fujitsu, Toshiba, Hitachi/Maxell, Epson, Mitsubishi, and others, range in storage capacity from as little as 16K bytes to as much as 16 megabytes. Because of their size and simplicity, they will become prevalent in featherweight computers.

But first the industry has to solve one critical issue: No standard physical, electrical, or logical formats exist for these cards. The dimensions

continued

NANOBYTES

The best **power source for portable computers** would be rechargeable lithium batteries, which would offer twice the voltage at half the weight of current batteries, says computer designer **George Morrow**. However, Morrow says, lithium is an extremely reactive metal, and the U.S. Environmental Protection Agency has refused to allow lithium batteries larger than AA size. The EPA is concerned with the possibility of larger lithium batteries, which explode more violently than conventional batteries, breaking open and releasing the metal into the environment.

Computer Professionals for Social Responsibility has issued a call for papers for its next symposium on Directions and Implications of Advanced Computing. The DIAC-90 conference will address "**ethical, social, and moral issues** in which computing plays a part." Papers should cover topics in general categories, such as direction and sources of research funding, defense applications, computers in a democratic society, and computers used for the public welfare. "Papers on ethics and values are especially desirable," a spokesperson said. Papers are due by March 1, 1990. The symposium is scheduled for July 1990 in Boston. Contact program chair Doug Schuler at (206) 865-3226.

IBM has brought its **4-megabit memory chips** to market on a board for upper-end PS/2 computers, making it the first PC product that uses the new, denser memory chips. The PS/2 Enhanced 80386 Memory Option, which works in Model 70s and 80s, comes in 2- and 4-megabyte versions, priced at $1795 and $3495, respectively. IBM says the 4-megabit chips, made at plants in Vermont, West Germany, and Japan, can access a bit of data in 80 ns.

NANOBYTES

Oki Electric (Tokyo) has joined the group of vendors working to develop a **multiprocessor version of Unix for Intel's 80386, 80486, and 80860** processors. Other members of the project are Intel, AT&T's Unix Software Operation, Olivetti, Unisys, and Prime. The software will conform to AT&T's System V Interface Definition. Intel said that the multiprocessor version will be ready for beta test sometime during the last quarter of this year and will be ready for commercial release next year.

Unix, Italian style: The Italian market for Unix-based systems will hit 1100 billion lira, or $750 million, this year, says the Italian research firm Mate. Last year, 30,000 Unix-based computers, worth 800 billion lira ($548 million), were shipped in Italy, a Mate report says. In 1987, 80286- and 80386-based systems running **Xenix** accounted for 71 percent of the units at Unix installations in Italy, but those machines have been gradually losing ground to engineering workstations, Mate's study shows.

OS/2 is such a good environment for developing code that **Jensen & Partners International** is now using it to develop all its products, said company president Neils Jensen during a demo of JPI's new C compiler. JPI is also using OS/2 to create MS-DOS versions of its compilers, said Jensen, who developed software at Borland International before starting his own company. OS/2 "could be very successful if IBM would push it as a developer's platform," Jensen said. JPI's latest developer's product is TopSpeed C.

Paul Mace, known for his eponymous company's line of software utilities, such as Mace Gold and Vaccine, will now be developing programs exclusively for **Fifth Generation Systems** (Baton Rouge, LA), which has taken over the ownership and marketing of Mace's commercial products. Fifth Generation is known for Fastback, Suitcase II, Pyro!, and other utility programs.

aren't standard, the electrical specifications (e.g., the voltage thresholds) aren't standard, and the logical format for storing and executing data and applications aren't standard.

In an effort to establish these standards, most of the memory-card manufacturers, some of the hand-held system vendors (e.g., Toshiba, NEC, and Poqet), and some major software companies (e.g., Lotus, Microsoft, WordPerfect, and WordStar USA) have set up a technical committee that will attempt to iron out a consensus. The committee is establishing technical and marketing groups to begin work on the standards as well as to promote memory cards as a competitive storage medium.

Competing technologies already in place will make it difficult to arrive at a single standard. NEC's UltraLite uses a 60-pin memory card that appears as an additional floppy disk drive on the computer; applications are loaded into system RAM and executed just as they would be from a floppy or hard disk drive.

The Poqet Computer memory card uses a 68-pin connector and executes the application directly from the ROM on the memory card. This configuration is supported by the Japanese Electronics Industry and Development Association (JEIDA), whose members include Fujitsu, Toshiba, Hitachi/Maxell, and Epson.

Agilis's hand-held workstation uses a proprietary format developed by Mitsubishi; it also formats the card like a floppy disk drive, but it is not compatible with the NEC approach. The memory cards in these various systems are not interchangeable.

These various formats and code-execution schemes mean that software developers have to write different versions of their software for each system. The easiest format, from a software developer's standpoint, is NEC's, which requires very minor modification of programs designed to run off floppy disk drives. The Poqet approach requires the software application to use a different memory scheme, which means that a developer has to make some code modifications to existing applications. However, the execution scheme supports LIM/EMS and will not require "a major rewrite if the code is written well," said Neal Chandra, vice president of business development at Poqet.

Software companies are eager to see a single standard. It would reduce R&D expenses and allow vendors to supply a single version of their software for all the different memory cards, said Jim Prelack, Lotus's manager of technical marketing for spreadsheets. And, of course, it would be nice if users could swap memory cards between different computers.

Despite the obstacles, there's optimism that a standard will emerge. Agilis marketing director Bert Keely said he thinks that the standard will be determined by which type of memory card has the most software installed on it. NEC marketing representative Jim Bartlett said he thinks there might be two standards: a standard for microcomputers based on NEC's design, and a "low-end" standard for calculators and other electronic devices, based on the JEIDA ROM-executable approach. Bartlett said that the JEIDA approach "is not applicable to this [the U.S.] market" because there is no installed base of machines supporting that standard in this country.

The standards can't come soon enough for product designers. As Fujitsu's John Reimer pointed out, "A whole generation of laptops and notebook computers are in the planning stages, and decisions are being made right now." Without standardization, memory cards will remain expensive, and software developers will be reluctant to tailor their software to them.

BIT Speeds Up SPARC with New Process

Bipolar Integrated Technology (Beaverton, OR) says it has produced the first emitter-coupled-logic (ECL) RISC microprocessor and claims that it's the fastest chip yet based on Sun Microsystems' Scalable Processor Architecture. The new 32-bit SPARC microprocessor runs at 80 MHz and executes 50 to 65 million instructions per second, the company says. The accompanying floating-point chip set can execute up to 40 million floating-point operations per second and offers a sustained processing rate of 14 MFLOPS, BIT says. That would make it comparable to Intel's new 80860 chip. Sun has said

continued

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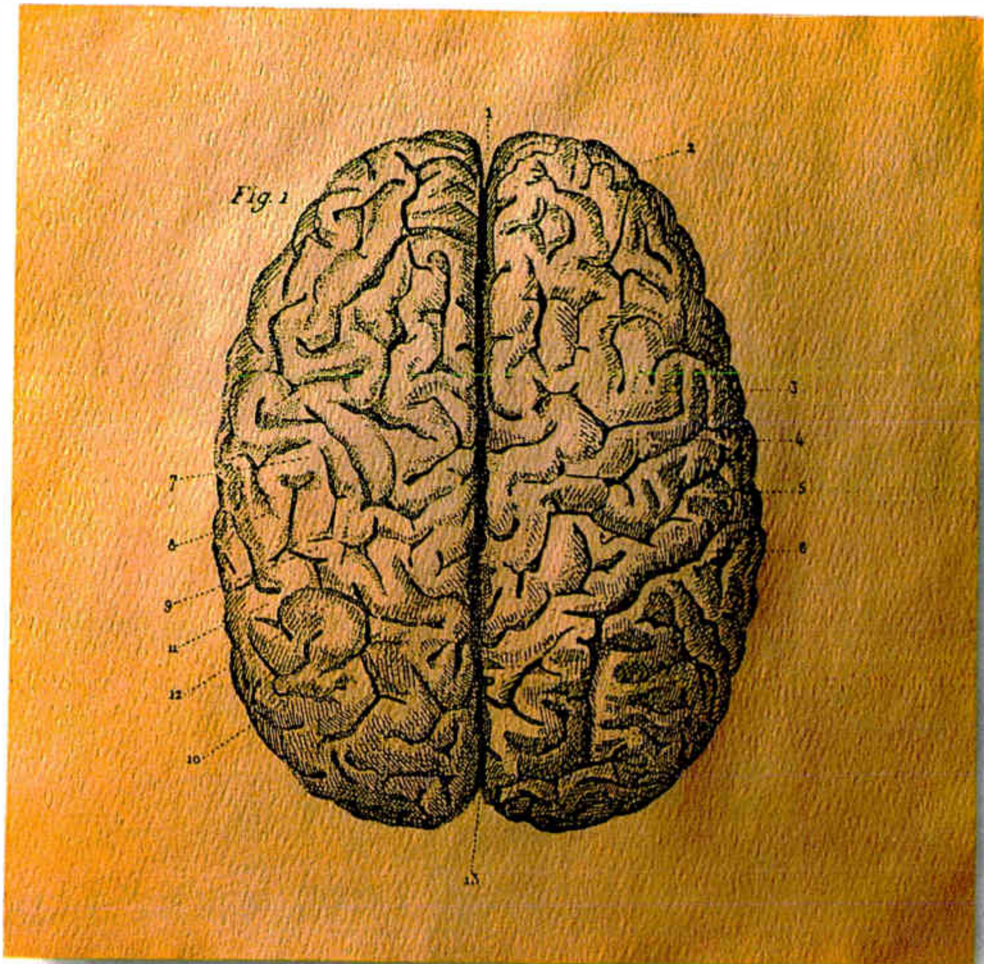

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that it has the BIT chips running now in its labs and plans to use them in future systems.

ECL designs have long offered higher speed than traditional TTL or CMOS chips, but they have suffered from higher power dissipation and lower gate densities. BIT claims to have solved these problems through a proprietary process called BIT111, which permits the company to make chips with the density of MOS chips and the speed of ECL chips.

The BIT111 process uses three metal layers and 1.2-micron lithography but employs conventional semiconductor manufacturing equipment, the company says. By reducing power consumption and reducing the size of transistors, BIT says it can squeeze as many as 250,000 transistors on a single chip.

The heart of the BIT chip set is the B5000, a 32-bit monolithic integer unit consisting of 125,000 transistors; it has been tested in the lab at up to 100 MHz, company officials say. The B5000 averages 1.2 cycles per instruction versus up to 1.6 cycles of instruction for previous SPARC implementations, according to information provided by BIT.

Portable with Color LCD First of More to Come

NEC has just started selling in Japan a portable computer with a supertwist color LCD. The 80286-based color computer has a list price of 748,000 yen, or about $5250. The 19-pound PC-9801LX5C, measuring 4.5 by 13.3 by 14.9 inches, comes with two 3.5-inch floppy disk drives and a 40-megabyte hard disk drive. The display, which measures 9 inches diagonally, supports resolution of up to 640 by 400 pixels and up to eight colors. Although the company does not have plans at this time to offer the new system in the U.S., the computer will soon show up on these shores in one form or another, and it won't be the only color-LCD portable on the market.

Other companies are readying color laptops for the U.S. market, including Sharp, which showed its PC-8000 earlier this year at CeBIT and Spring Comdex. The 80386-based Sharp machine has a 14-inch color screen capable of showing 16 colors from a pallette of 512 at a resolution of up to 640 by 480 pixels. This portable is expected to be available early next year and to cost closer to $10,000, though the price has not been set yet. The backlit Sharp screen uses a series of tiny glass filters that "reflect" the basic red, green, and blue color components.

Hitachi has shown a prototype 6-inch active-matrix color screen installed in a computer but has not disclosed any product plans. The company is selling the display to other manufacturers, though, for about $2200 each. Hitachi's prototype screen manifested one of the problems that's still bugging active-matrix technology: It's hard to produce a perfect model. A careful observer could see that a few pixels were not working properly; active-matrix displays look great, but even one faulty transistor among several hundred thousand can result in a bad pixel.

Toshiba has made no product announcements but has shown prototypes of active-matrix color displays, one 11 inches wide and the other 14 inches. At last viewing, the display was crisp but fragile; company representatives at Spring Comdex would show the display for only 2 hours each day.

George Morrow Readying New Computer

Four years ago, George Morrow was busy designing a portable computer called the Morrow Pivot, probably the first of the so-called lunchbox computers. Now the industry pioneer is working on another laptop, one that he promises will be ready for next month's Fall Comdex.

Morrow's new machine will be a conventional laptop, rather than a "pocketable" computer like those announced by Poqet and Atari, or a hand-held system like the NEC UltraLite, the Zenith MinisPort, and similar machines coming soon from the likes of Toshiba. The CPU will be an Intel 80386SX, a chip that Morrow

continued

NANOBYTES

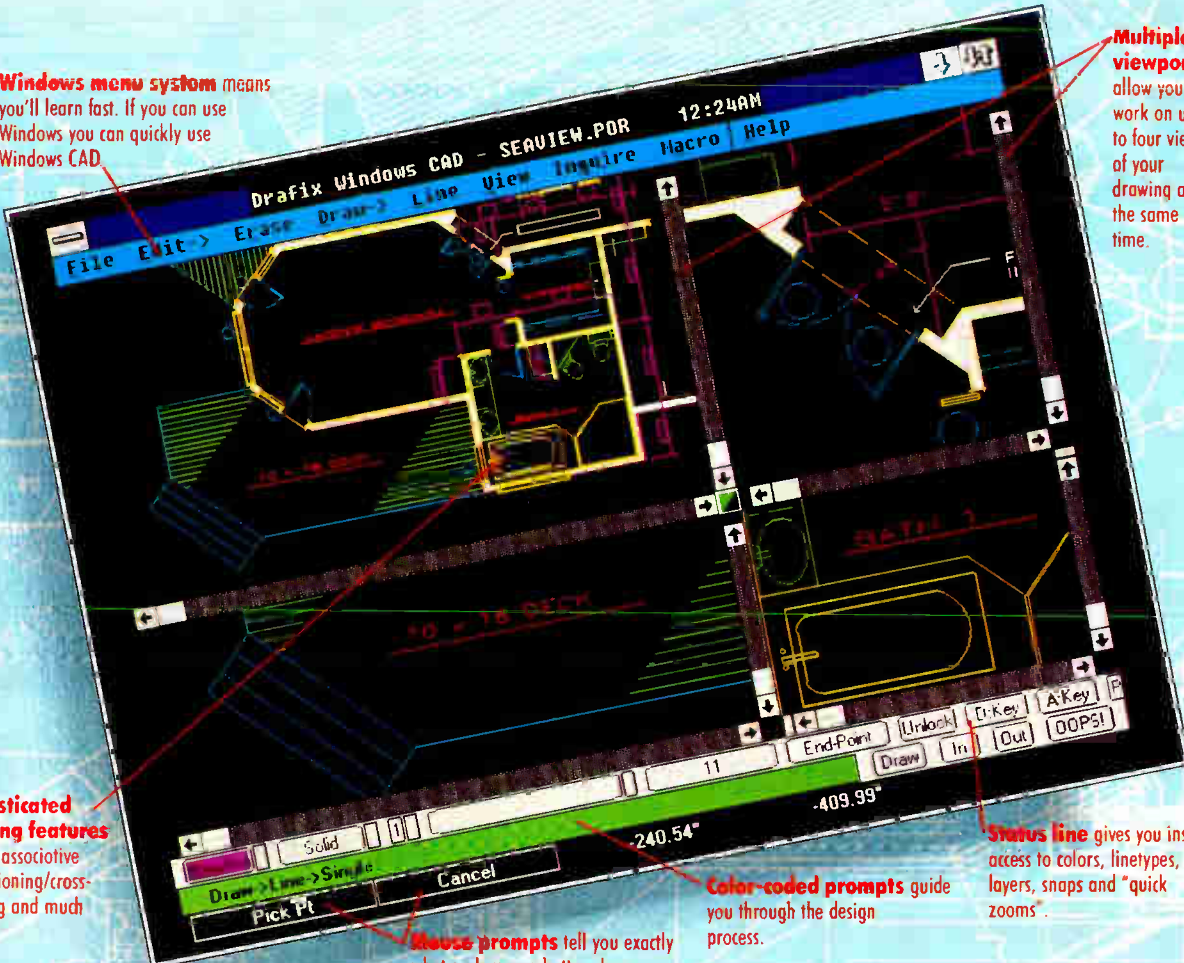
If you've ever had the **battery in your PC AT die**, you know how painful *that* can be. The lithium batteries in most ATs are good for a year or two, but once they croak, new ones are hard to find. **Rupp** Corp. (New York, NY) now has a nice means of insurance: a rechargeable backup battery for AT-type computers. Rupp's bATPac ($39.95) continually charges itself while your computer is on and will last for at least 10 years, the company says.

Data General's Aviion computers, based on Motorola's 88000 RISC processor, will be able to run **DOS applications**, thanks to a deal DG (Westborough, MA) signed with **Phoenix Technologies** (Norwood, MA). Phoenix will develop a version of its OpenPC software that will enable the DG systems to run DOS programs simultaneously with Unix programs.

NCR Corp. (Dayton, OH) and **IMC Networks** Corp. (Tustin, CA) are teaming up to develop a **32-bit Ethernet card** that will take advantage of the Micro Channel architecture's bus-mastering capabilities. The communications card will be built around NCR's 32-bit Ethernet controller chip, the 92C28. The forthcoming PCnic MCA bus card will comply with IEEE 802.3 Ethernet standards and will work with both thick and thin coaxial cable. The companies say the card will be out this quarter and will sell for $995.

Data Translation (Marlborough, MA) has **dropped prices** of its image processing and data acquisition products by as much as 25 percent. The DT2853-SQ PC AT Frame Grabber, for example, has gone down from $1895 to $1595, and the DT2817 PC Digital I/O Board has gone from $239 to $215.

AST Research (Irvine, CA) **lowered prices** on its computer systems with hard disk drives. The Premium 386/25 Model 95, for example, dwindled in price to $7195, a drop of $1100. AST also lowered the price of its hard disk drive upgrades.



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Smalltalk/V

Circle 85 on Reader Service Card

NANOBYTES

NCUBE (Beaverton, OR) has started shipping what it claims is the **fastest supercomputer in the world**. The massively parallel NCUBE 2 can be outfitted with as many as **8192 processors**; with that many of the 64-bit processors working together, the system can execute 60 billion instructions per second and 27 billion scalar-point operations per second, the designers say. NCUBE plans to have a version of Unix running on the supercomputer. **Oracle** has already said that it will port its database management software to the parallel system. The NCUBE 2 starts at $495,000.

Remember **CEBus** and the **Smart Home**? CEBus is a set of specifications for encoding and transmitting information over AC power lines. Home-electronics makers hope to design 'smart' appliances that talk to each other. But there's been 'embarrassingly little change' since CEBus made its debut in January, said Bob Garry of Diablo Research, one company working on the CEBus technology. Problems involving the networking of appliances over AC lines have yet to be ironed out, he said.

Vapor chasers: An **Ashton-Tate** attorney recently sent a letter to **WordTech** demanding that WordTech cease and desist marketing a product called dBASE/SQL. "Please be advised that your use of the 'dBASE' mark consitutes a violation of Ashton-Tate's federally registered trademark," wrote the ever-vigilant A-T attorney on the case. The letter demanded that WordTech, which makes products that integrate its dBASE-compatible DBXL with SQL, change the name of dBASE/SQL and destroy any materials that refer to dBASE/SQL. Fulfilling the A-T mandate will be tough: WordTech says it doesn't make a product called dBASE/SQL. Company president David Miller referred to "dBASE/SQL" as "**the ultimate vaporware**, since it's unannounced, undesigned, undeveloped, unknown, has no marketing plan, sales plan, packaging plan, nor any release date or pricing."

technology could "provide the Soviets with sufficient advancements in military design, which in turn would make it even more expensive for the U.S. to maintain a military advantage," said one member of the State Department.

The State Department's clarification of its stance coincided with meetings being held by the Coordinating Committee for Multilateral Export Controls in Paris. COCOM is the organization of NATO countries that oversees technology trade with the Eastern Bloc. Most COCOM representatives have favored loosening export restrictions to the USSR, if for no other reason than because they don't think the restrictions are working. Prohibiting export of AT-style machines had "become almost impossible to enforce because they are available through so many sources," said Frank Deliberti of the Department of Commerce's Office of Export Enforcement.

Intel Delivers EISA Chips to System Makers But Says Bus Won't Drive Users' Choices

Ten months after nine computer makers said they didn't need IBM's Micro Channel architecture (MCA) and announced their own 32-bit bus standard, Intel officially introduced the chips that will make the Extended Industry Standard Architecture a hardware reality. Computer makers adopting the EISA bus said that they'd have EISA-compatible systems ready by Comdex next month.

The new Intel EISA 82350 package consists of four chips. The 82357 incorporates enhanced direct-memory-access control, a timer/counter, interrupt control, bus arbitration, and DRAM refresh functions on a single chip. Intel says the chip offers a maximum DMA transfer rate of 33 megabytes per second, which is more than eight times faster than the transfer rate of the AT bus. By comparison, the MCA bus has a maximum data transfer rate of 20 megabytes per second, according to Intel. The 82357 also handles bus arbitration.

The 82358 EISA bus controller interfaces with the 8-/16-bit AT bus, the 32-bit EISA bus, and the host CPU bus. It will allow existing AT boards and the future EISA boards to coexist in an EISA system.

The 82352 EISA bus buffer is used to integrate the data swap logic, the address buffers, and the data parity buffer. It's designed to integrate approximately 17 components, thus lowering the system board chip count and cost. According to Intel, the 82352 chip is intended for those system manufacturers seeking higher integration on the system board.

The 82355 bus-master interface controller acts as an interface between the local functions of the bus-master card and the EISA bus-master protocol. The 82355 "arbitrates" for bus ownership and can take control of the bus from the host CPU for bus-intensive tasks, such as database management and high-performance file serving.

The new chip set won't add much to the cost of an EISA system, Intel said. At current prices, the EISA chips would increase the cost of a machine by $50 to $100 over an AT system, according to Intel. Company officials predict that by next year, EISA and MCA chip sets will cost the same as 16-bit AT chip sets, hence increasing the allure of 32-bit systems.

But Intel officials say the decision to buy an MCA or EISA system will ultimately be based on factors other than bus technology. These factors include loyalty to a particular manufacturer; prices of competing systems; proprietary features that manufacturers say increase performance of their systems; and 'geopolitical considerations,' purchasing decisions based on nontechnical or emotional issues.

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LETTERS

and Ask BYTE

Who Invented the Computer?

How can John William Mauchly Jr. (Letters, July) write an 800-word letter on the Atanasoff/Mauchly controversy (Book Reviews, September 1988) without acknowledging the court decision in *Honeywell, Inc.* v. *Sperry Rand Corp., et al.*, of October 1973?

Here is the record, developed in a trial lasting more than two years. Section 3 of Judge Larson's opinion states, among other things, that "Eckert and Mauchly did not themselves first invent the automatic electronic digital computer, but instead derived that subject matter from one Dr. John Vincent Atanasoff."

Mauchly the younger claims "ample evidence to the contrary." He mentions a letter, an experimental counter, and several unnamed students. Sperry Rand, in a case involving million-dollar patent rights, would not or could not produce any such evidence for the record. Instead, the court record shows a letter from Mauchly requesting permission to incorporate Atanasoff's ideas. If Mauchly's evidence is so clear-cut, why didn't Sperry use it to preserve its patent? Why didn't Sperry appeal the decision?

Anyone wishing to form an independent judgment should read Clark R. Mollenhoff's 1988 book, *Atanasoff: Forgotten Father of the Computer.*

George Wright
("georgew" on BIX)
Lutherville, MD

Warning Optional

We would like to commend Martin Heller for "Breaking the Memory Barrier with 386|VMM" (July). MicroEMACS consists of more than 570K bytes of C source code, and Heller only had to change 34 lines of code to compile it in MetaWare High C for both protected mode and virtual memory mode, either of which will access 4 gigabytes!

Our only complaint is that he didn't mention the compiler switch to turn off warning announcements. We think that warnings are a good thing, but if a user doesn't like them, they switch right off.

Heller will be happy to know that most of the minor changes he required are already in beta test here at MetaWare. We don't agree that old 8086 methods are best, particularly in this new 80386 arena, but programs are daily being migrated to the 80386 via High C. We will supply the functions to make conversion easy, and then lobby for better methods.

Steve Blackwell
Product Group Manager
MetaWare, Inc.
Santa Cruz, CA

WE WANT TO HEAR FROM YOU. *Please double-space your letter on one side of the page and include your name and address. We can print listings and tables along with a letter if they are short and legible. Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

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Mac OS Wish List

My wish list for the Mac OS would include two items Don Crabb didn't mention ("The Mac Interface: Showing Its Age," Macintosh Special Edition, June): a simple but powerful text editor, and a print spooler for dot-matrix printing.

The TeachText editor that comes with the Mac operating system is too rudimentary to be much more than a toy. Its most serious problem is that it cannot reformat paragraphs that contain carriage returns at the end of each line. Simple text-file transfer among arbitrary computer systems requires the use of such files (i.e., those that end in hard returns). A capable text editor, preferably one that can edit multiple files at the same time, is an essential aspect of any operating system. Of course, the DOS EDLIN hardly qualifies; the Unix editor, vi, is only a slight improvement over EDLIN; and the Windows notepad has even more limitations than TeachText, so my opinion on this seems to be out of favor with operating system vendors.

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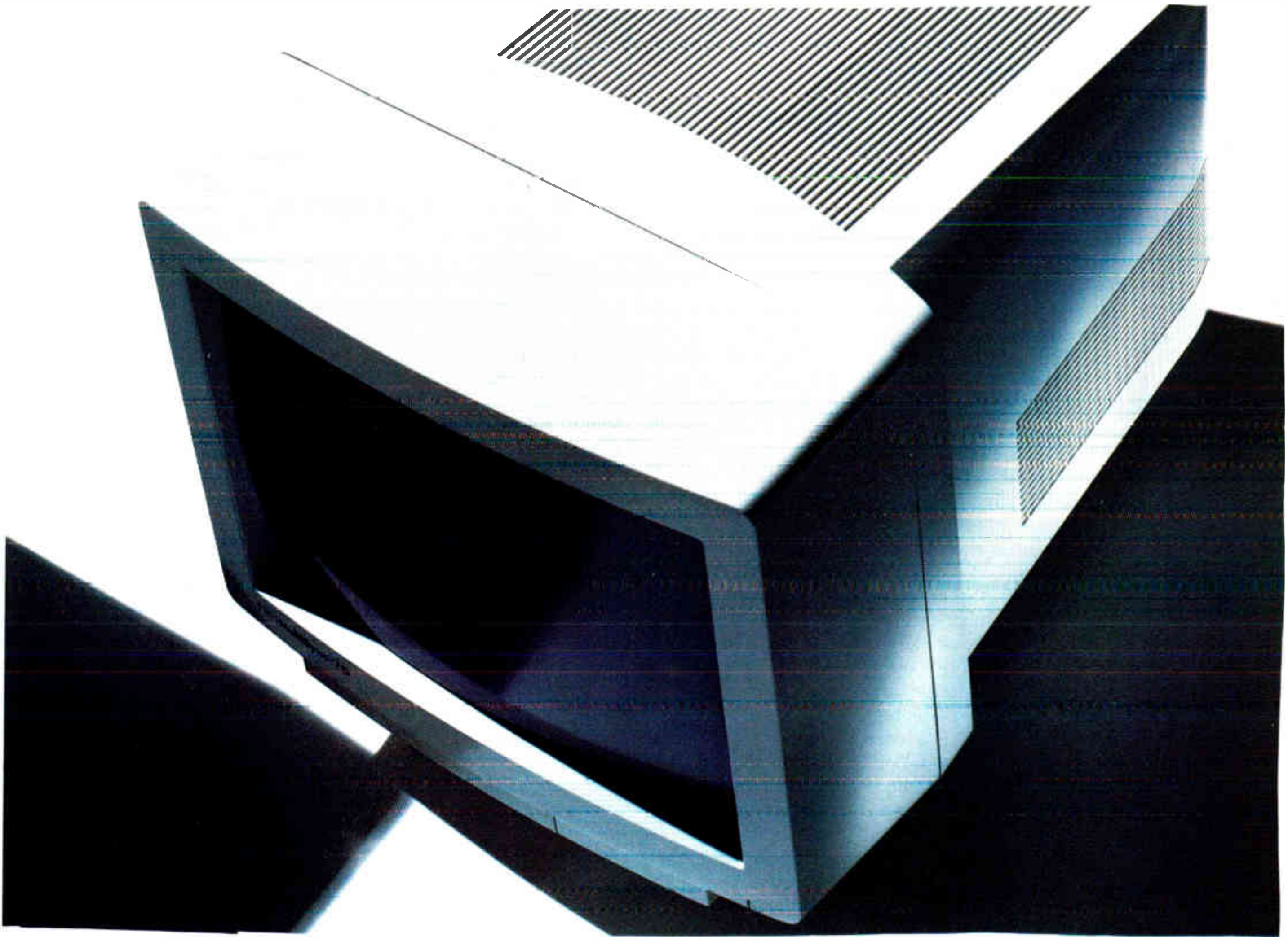

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is not significant unless you are dealing with numbers larger than any that would occur in business applications. To be sure, floating-point is superior for transcendental functions. However, if you don't need high accuracy (e.g., in graphical display), fixed-point with lookup tables (e.g., for sines and cosines) will outperform floating-point. True algebraic operations, such as square root, are performed about the same in both.

The main distinction between fixed-point and floating-point programming arises in the storage of variables. Programming general-purpose modules requires you to anticipate exceptional cases. A floating-point variable occupies a fixed amount of memory. When there is insufficient space to carry out operations correctly, floating-point simply gives a wrong number. Try $x \times x - (x + 1) \times 8 (x - 1)$ where x fits accurately but x^2 does not. In fixed-point, however, intermediate operations may overflow any prescribed size. Thus, fixed-point requires dynamic memory allocation; the amount of memory set aside for the storage of a variable varies with the size of the variable and changes as the variable changes. The DOS file allocation table is a standard example of dynamic memory allocation. A little extra programming is required, but there is little loss of speed in most applications.

Numerical coprocessors change the picture. For intensive number-crunching, a floating-point coprocessor like the 80287 is much faster at fixed-point operations than is the 80286. There are several reasons for this. First, the 64-bit registers of the 80287 are effectively twice as fast for all arithmetical operations than the 16-bit registers of the 80286 if you're dealing with integers with more than 16 bits. Second, the hard-wired code on the coprocessor operates much more quickly than code fetched from memory. Third, with optimized coding, you can store variables in the 80287 stack rather than having to move them around in memory. The last two differences would matter less if you had a high-speed cache memory. Fourth, you can, with good coding, do coprocessing; the 80286 can compute the address of the next variable needed from memory while the 80287 is doing arithmetic. Finally, the overhead required for handling the variable size of fixed-point numbers adds up over thousands of iterations.

My original motivation for getting an 8087 was for use in a program where I had to deal with fairly large integers and didn't want to take the time to construct code for fixed-point operations. Alas, the numbers got too big—beyond the 64-bit limit—and I needed exact answers.

Carl Herz
Department of Mathematics and Statistics
McGill University
Montreal, Quebec, Canada

There now, see? With a little effort, you can extend my floating-point package to as many significant digits as you need. Yes, it would be slow—but it would work. —Rick Grehan

Uncrackable Code?

The writers of the articles on security (In Depth section, June) consider it unsatisfactory to use a password that initiates a word-substitution program. The procedure, of course, is quite pedestrian. I have worked on these matters as a hobby and have come to use an algorithm that encrypts a text in such a way that I defy anybody to crack the code.

The secret is to take an obscure text of 200 words or so and "add" this text letter for letter to the text to be encrypted, producing a new ASCII code for each character of text. The "password text" is never stored on the hard disk but resides on a floppy disk that you insert when you want to do encoding and decoding.

No common analyses of letter frequencies would help you decode this encrypted text, because the translations change all the time: In one case, "a" may be represented by ASCII 202; in another, ASCII 72; and so forth.

Paul A. Elias
Fountain Hills, AZ

Your method is in effect a one-time pad, which is, indeed, a foolproof system when used properly. However, there's a flaw in your application. For the one-time pad method to work, the encryption text must be used just once. Therefore, it must be at least as long as the original text, and it cannot be reused for multiple encryption processes. If it is, sophisticated methods of pattern recognition and frequency analysis will leave the encrypted text open to decipering.—G. A. S.

ASK BYTE

I Love This Machine, But...

I purchased my IBM PS/2 Model 50 Z in August 1988, and up until about two months ago I had no problems with it. But since then, whenever I start up the computer, it gives me a `1782 error` message and directs me to the DOS manual for further information. The book told me to do a system test, so I did. The test reported a parallel port error. So I took the system to an authorized IBM center. A technician spent a week checking the CPU and the ports and found nothing. She then said that since a 1782 error is a hard disk error, she would like to format the hard disk to locate the problem. I reluctantly agreed. The check found nothing wrong. I took the system home and got it running again. Guess what? About a week later, the error came up again.

This was very frustrating, especially since the IBM center did not find anything wrong with the system. I should also mention that if I turn the computer off and back on again (sometimes several times), the error does not occur and the machine operates correctly. Rebooting doesn't work, so I am worried about constantly turning the system on and off.

Son C. Nguyen
Boston, MA

The `1782 error` *message actually refers to the hard disk drive controller card. The IBM PS/2 series of computers is unique partly because the IBM engineers tried to minimize the use of connecting cables. The hard disk drive in your Model 50 Z plugs directly into the hard disk drive controller card. You mention that the problem goes away after turning the computer on and off several times; the problem may be due to an intermittent connection in the connector between the hard disk drive and the controller card, between the controller card and the system bus, or within one of the chips on the controller card. The problem goes away after you turn the computer on and off because the internal components in the computer are "warmed" to their usual operating temperature and the thermal expansion of the components finally makes the electronic connection.*

I suggest that you remove your hard disk drive and controller card from the computer and clean the card edge connectors. Use a commercial electronic contact cleaner or denatured alcohol. Also, if there are any DIP chips on the card, make sure that they are firmly seated in their sockets. Then plug the card and drive back into your computer.

If the problem persists, have your IBM dealer test your hard disk drive controller card in another Model 50 Z.—S. W.

Database Security

I am a graduate student in computer science, and I'm currently working on a

continued

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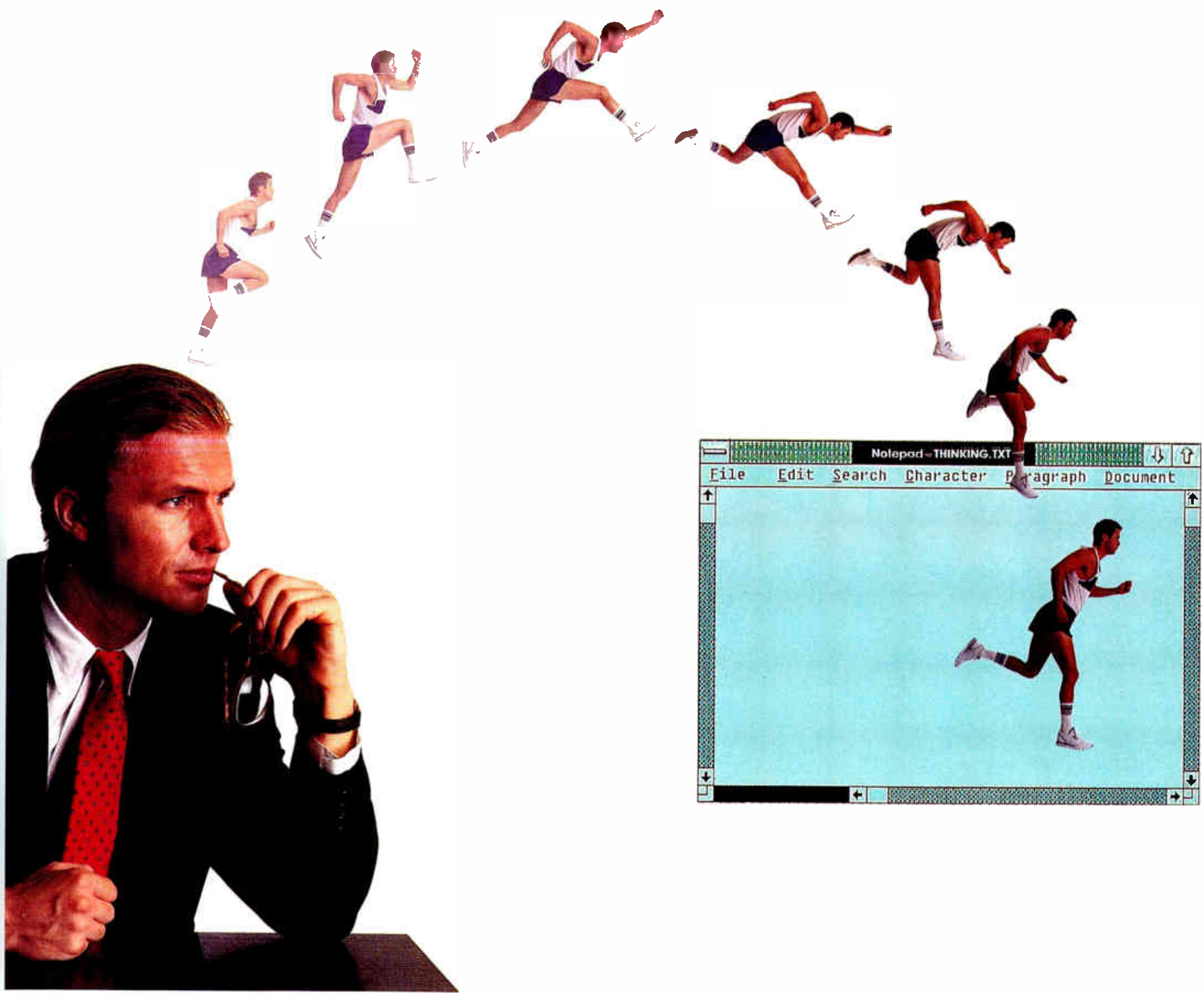


C&C Computers and Communications

NEC

Circle 190 on Reader Service Card

research paper on database security. I'd appreciate it if you could provide me with any information on the subject.

Earnest D. Harris
Memphis, TN

Your first stop should be BYTE's June issue, in which the In Depth section is devoted to security. Next, see if you can locate a copy of DataBase Management Systems, *edited by R. A. Frost (McGraw-Hill, 1984), which contains at least one case study focusing on database security. Finally, be on the lookout for* Computer and Communications Security *by James Arlin Cooper (McGraw-Hill, 1989), which includes discussions of network-systems security.*—R. G.

The Leap from Apple

I have a number of disks in Apple CP/M, formatted on an Apple II with 16 sector drives and a Microsoft Z80 SoftCard. The SoftCard Apple CP/M is a 60K-byte version 2.23. I would like to transfer the disks to an IBM PC XT running PC DOS 3.3. They contain programs in dBASE II, as well as files that I created with WordStar. I have tried using Xenocopy, but the Apple II is not among the systems that it supports.

M. S. C. Ong
Seremban, Malaysia

Whenever I receive a letter about file transfer between dissimilar machines, my first suggestion is always: Locate a public domain communications program for each machine, put a serial port together, and shoot the files across that way. That's usually the cheapest way to go; it involves some investment in time and a minimal investment in hardware. (I am, of course, presuming that both machines already have RS-232C interfaces installed.)

Depending on how much you're willing to spend, you might also want to look into PC Transporter from Applied Engineering (P.O. Box 5100, Carrollton, TX 75011, (214) 241-6060). Not only will you be able to copy files between Apple and PC format disks, you'll be able to run the programs on your Apple II.

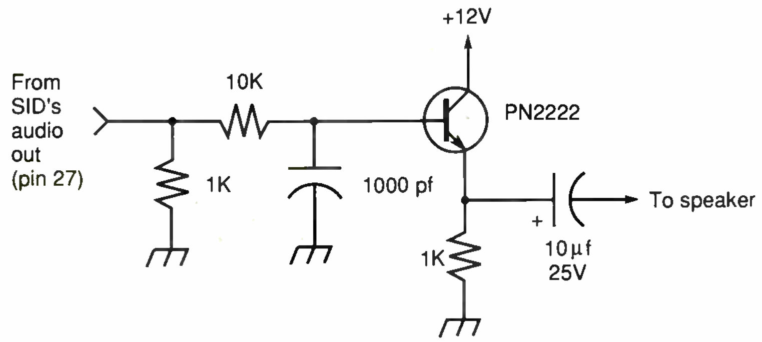
—R. G.

PC Music

I want to build a music synthesizer on an IBM PC expansion board, using a number of dedicated chips such as the 6581 sound interface device (SID) found in Commodore machines. Are there other similar devices more appropriate for use on the PC bus? Alternatively, what sort

continued

A SIMPLE AUDIO AMPLIFIER



An audio amplifier circuit for the 6581 sound interface device (SID).

of adaptations must I provide to interface the 1-MHz 6581 with the PC bus?

Ivo Busko
Baltimore, MD

I might be telling you something you already know, but before you go putting together your own music synthesis card for the PC, you should look into the possibility of purchasing (or building) a MIDI interface for your PC. You'd probably get a lot more mileage out of MIDI than a do-it-yourself synthesizer card. Manufacturers of MIDI interfaces for the PC include Music Quest, Inc. (2504 Ave. K, Suite 500-492, Plano, TX 75074, (214) 881-7408), Roland Corp. (7200 Dominion Circle, Los Angeles, CA 90040, (213) 685-5141), and so many more that I wouldn't have space for them all. Locate a recent issue of Electronic Musician *magazine and do some browsing. You'll find plenty of possibilities.*

If you want to build your own MIDI adapter, "A MIDI Project" in BYTE's June 1986 issue should fill the bill. I've even heard of people modifying ordinary IBM PC serial interfaces to work with MIDI. Key Electronic Enterprises (9112 Hwy. 80 W, Suite 221-E, Fort Worth, TX 76116, (817) 560-1912) makes a device that operates off PC serial ports.

Finally, if you're simply desperate to put the 6581 SID into your PC, you could probably do it by building a parallel I/O board with an 8255 on it and controlling the inputs to the SID through the 8255's ports. As you've already noted, you'll have to include a 1.0-MHz source for the SID chip (easily done with a crystal from Jameco or JDR Microdevices).

For details on how to put together the 8255 interface, locate a copy of Handbook of Software and Hardware Interfacing for IBM PCs *by Jeffrey P. Royer (Prentice-Hall, Englewood Cliffs, NJ,*

continued

1987). A simple audio amplifier circuit for the SID (as suggested by Commodore) appears in the figure. To keep digital noise out of the audio stage, be sure your ground connections for the SID and the amplifier stage are separate from the grounds used by the 8255 and its attendant support circuitry.—R. G.

More Megabytes

In January, I purchased—through mail order—Digital Electronics Company's DE386 20-/25-MHz Desktop VII computer with 1 megabyte of RAM. Since April, I have been unable to contact Digital Electronics (the company *was* located in Rockville, MD). Certified mail that I have sent to the company remains unclaimed and is returned to me.

Basically, my system performs without problems, although the turbo mode—which is supposed to speed up the system to 25 MHz—causes all my programs to freeze.

I am in desperate need of more RAM. The manual that came with the machine reads, "The system memory board will support up to 16-Mb of 32-bit expansion memory through the use of special Digital Electronics expansion memory boards which attach to the main memory board in piggy-back fashion." The memory board, now fully loaded with 2 megabytes' worth of 256K-byte chips, is manufactured in Taiwan and is imprinted with the following information: ET-3 Pulsar MDS USA87, serial number P8706306.

Do you have any information regarding Digital Electronics Company? If not, what is the best way for me to upgrade my existing 32-bit memory board to its full potential? Obviously, I'd be happiest if I could find a compatible piggyback board.

Daniel Kalmann
New York, NY

You're about to embark on one of the more interesting aspects of owning a personal computer—the care and feeding of orphans. The memory expansion on most of these AT clones is proprietary to the manufacturer. I've called around and have been unable to reach Digital Electronics or locate anyone with information on your motherboard. What to do?

First off, I'm guessing that you added 1 megabyte to your machine, bringing it up to 2 megabytes. Is the memory you added fast enough? Is it from the same manufacturer as the original RAM? Yes, it matters. Japanese RAM has different timing than American RAM. When you push a processor at 25 MHz, the subtle timing differences can become significant. You might try substituting different RAM chips for the ones that you added. Another sad fact is that many of these boards simply won't work at their "turbo" speed no matter what you do.

If it were my machine, I'd forget about expanding the system board and buy a memory card for the bus. The Intel Above-Board, the Everex RAM 3000, or any good memory card may work. The memory will run a bit slower (being out on the bus), but you have the added advantage of being able to move the memory from this machine to another if this one ever dies. Depending on the BIOS, you may not even be able to add RAM on the bus.

The safest way would be to take the machine into a good computer store and try the memory card right in the store. If you buy a card mail order and it doesn't work, well . . .—H. E. ■

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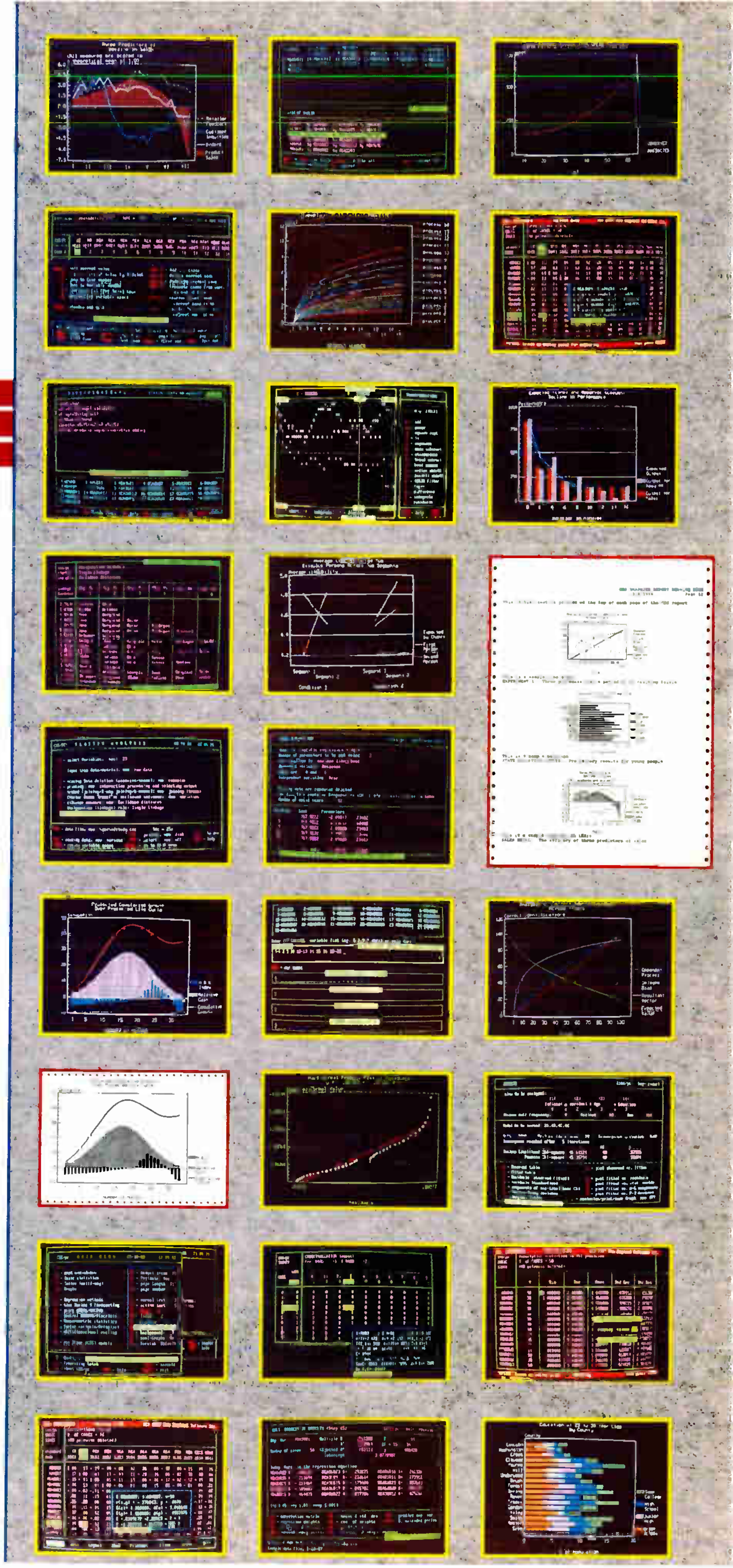

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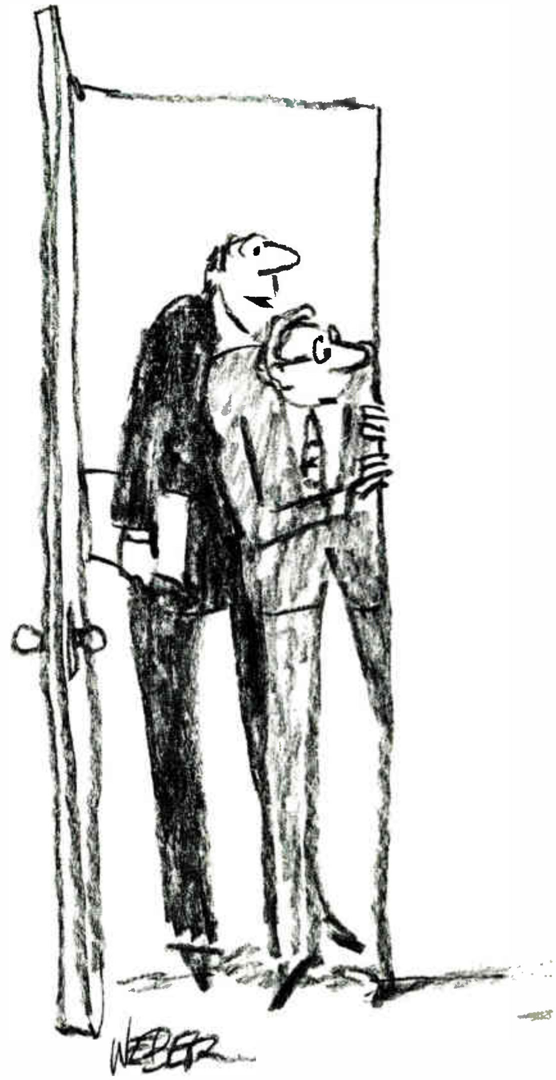

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CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

ST Lacks Fax

Dear Jerry,

As an Atari ST owner, I'm aware that there doesn't seem to be any possibility of inserting a fax card into my machine, since there are no slots. However, there is a modem port. Could you please explain if there is some way of composing a document in memory and some describable protocol to send it to a fax receiver via a modem?

Also, are there any 9600-bps or higher fax machine protocols? Would the same protocols work for digitized documents, and are there different resolution standards? What else would be required to receive and store fax messages in memory, so they could be displayed on a monitor instead of having to be printed? We're all bracing for the coming fax revolution, and we're planning to get a digitizer for desktop publishing. It seems that with the proper elements we should be able to do both faxing and DTP, but it would help to know exactly how to make them work together properly.

Frederick Bernard
Vancouver, BC, Canada

Sorry, but I don't know of any way to do that. Perhaps one of BYTE's readers will know. They seem to know everything. —Jerry

Face-Up vs. Face-Down Output

Dear Jerry,

Recently you complained about the face-up output of your LaserJet Plus printer. We have a similar machine at work, and it has a feature that enables you to switch the output between face-up and face-down. There is a two-position lever to the right of the output slot with some indecipherable symbols indicating this function. In one position the printer outputs each page face-up; in the other, it outputs face-down. I hope this reduces future problems.

Dave Swanson
Elgin, IL

Hmm. My LaserJet Plus is an original LaserJet (I got it way back in CP/M days!) that was upgraded to a Plus, and it certainly has no such switch. The LaserJet II has that option, of course. So does our big Kyocera printer and Mrs. Pournelle's Mannesman-Talley printer.

I have long thought that I ought to put the LaserJet Plus downstairs for the staff and bring the Kyocera up here; it's much the superior printer, so why should they have it? The only reason I can give for not having done it is sloth (and I don't do that much printing up here; most of it is done downstairs on the Tandon computer and the Kyocera printer).—Jerry

Windows in Monochrome

Dear Jerry,

The March issue of BYTE was full of good news for those of us who use and like Microsoft Windows. Mark Minasi reported on Micrografx's Mirrors, Ray Valdés reviewed XVT, and you had the wisdom to name Windows the Software Trendsetter of 1988.

Windows has its problems (how is it possible to design a graphical interface that doesn't manage the most graphical data structure, the directory tree?), but it does many things DOS can't, and at a far lower cost than OS/2. It even runs well on systems that can't run OS/2.

I would like to make some observations on your comment that you can get Excel and MacInTax for your AT, "provided you have a good EGA video system." Neither Windows nor Windows applications require high-resolution color. In fact, using an EGA or VGA color video system will slow down Windows considerably.

I have an AT&T PC 6310 AT compatible. It runs at 8 MHz with one wait state and has a 16-bit video card that provides a 640- by 400-pixel monochrome

continued

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

display. This is hardly state-of-the-art technology, but it runs Windows very well. I've been trying out Windows software on systems that run far faster, have far more memory, and are equipped with fast 16-bit VGA cards. Windows' performance on these machines is miserable.

When you think about it, it's apparent why a high-resolution color video system slows Windows down. The CPU must deal with a much larger video RAM space and an equally large screen buffer in main memory. A monochrome display represents a far smaller load on the CPU. Unless your work absolutely requires color output, you should run Windows in a monochrome mode (I believe Microsoft supplies graphics drivers for the EGA 640- by 350-pixel and VGA 640- by 480-pixel monochrome modes).

A solution to this problem will probably come in the form of video coprocessors (I have this fantasy of an Amiga 500 motherboard as an AT video card). Until then, we should remind ourselves that black-and-white is different, not worse.

Noah Jacobs
San Francisco, CA

Well, but I sure do like color.—Jerry

Low-Cost Compiling

Dear Jerry,

I enjoy your Computing at Chaos Manor column. It was the column that originally sold me on BYTE, and it remains BYTE's major attraction. I appreciate your hands-on reviews and your willingness to express your opinions.

I'd like your advice and/or a reference to an appropriate review regarding the various C compilers on the market. I have experience with FORTRAN (college, circa 1970) and interpreted BASIC. I've been working with a Unix-based system in my office, and I've started learning some C with the AT&T System V compiler. I'd like to buy a C compiler for my AT clone at home. However, the advertised prices in BYTE range from $50 to $400, with only advertising copy for comparison. Can I get a potent compiler without breaking the bank?

Nic Steussy
Springfield, TN

Thanks for the kind words. BIX is getting less expensive because of new marketing techniques, and it's the ideal place to ask questions like this.

I am no C authority. I understand that Borland's Turbo C is very good and reasonably priced. After that, you'd better get more expert advice. BYTE did a Product Focus on C compilers in the February issue. There are a lot of C compilers, and they are not all equal.—Jerry

Amiga Notes

Dear Jerry,

I'm one of the great unwashed who scrimped and saved and finally splurged on an Amiga 1000 after your first very positive BYTE review. I've been reading your comments since then with some concern, and I have to agree that they've been fair and factual. Nonetheless, I was glad to see your report on more positive developments such as Unix, because despite everything I've grown rather fond of my idiot child.

It's fun to read your column and dream of being surrounded by great snarling 80386 beasts, as at Chaos Manor. I hope someday you'll install a 68030 board in your Amiga 2000, because, chip for chip, it is said to have four times the computing power of the 80386.

I often think your asides about the concrete problems of setting up an "ergonomic" work environment are your most useful and lasting contributions. I constantly use the copy holder I kludged onto a drafting light fixture after seeing you using something similar in a photograph taken eons ago. In addition to the wide, flat desk for global input of paperwork, I recommend cheap cork tiling on all walls not occupied by bookshelves. It holds reams of stuff you don't want to rummage for and provides a resilient surface for your skull during debugging.

Charles Heckel
Van Nuys, CA

Thanks.—Jerry

All Thumbs

Dear Jerry,

You responded to James T. Oitzinger's suggestion (April) that dividing a keyboard's space bar into two parts might result in a better keyboard by saying, "That sounds like an interesting idea. I've been watching, and I hardly ever use my left thumb for anything. Fascinating. Thanks for the suggestion."

I, too, thought it was an interesting idea, so I read Oitzinger's letter to my wife. Her response was that the left thumbs of keyboard users must be kind of lazy, because her (old) bassoon has eight different keys controlled by her left thumb, and sometimes she must depress four or five of them *at the same time.* (She also said that newer bassoons have nine keys for the left thumb.)

That really makes me appreciate my one-bar-for-both-thumbs keyboard!

Dr. Myron A. Calhoun
Manhattan, KS

Right! I'm using a Northgate keyboard, with the Backspace key where it belongs (up there where the [ ] keys are on other keyboards). Alas, they only made about five of them, and I think I have them all.

—Jerry ■

MCA Clones from France

The NS70-25 is a small Micro Channel architecture-compatible 25-MHz 80386 desktop system from France. Other NS systems include a 16-MHz 80286, a 16-MHz 80386SX, and a 20-MHz 80386.

All these machines use a proprietary Normerel BIOS; the company calls it "multilingual," because it is user selectable at setup to English, French, Spanish, or German. The NS70-25 includes 1 megabyte of RAM (upgradable to 4 megabytes), a 64K-byte disk cache, and one 1.44-megabyte floppy disk drive (with support for another 3½-inch internal drive and a 5¼-inch external drive). The standard hard disk drive is Quantum's 84-megabyte SCSI-based drive with a 19-ms average access time.

Included in the NS70-25 package is a 102-key PS/2-style keyboard and DOS 3.3. A 140-megabyte hard disk drive is optional.

The 16-MHz NS machines include your choice of 40- or 80-megabyte SCSI drives, but they don't include disk caching.

Price: NS70-25, $7229.
Contact: Normerel USA, Inc., 7665 Currency Dr., Orlando, FL 32809, (800) 940-8500 or (407) 240-8828.
Inquiry 1135.

Normerel's 25-MHz NS70-25 has an MCA bus.

DEC Gets Low on RISC

The DECstation 2100 is a low-priced small-footprint RISC system. It's based on the 12.5-MHz R2000 processor from MIPS Computer Systems, and it includes 8 megabytes of RAM (expandable to 24 megabytes), a 15-inch monitor with 1024- by 864-pixel resolution, a thick and thin Ethernet interface, a mouse, a keyboard, and Ultrix Workstation Software, which includes an Ultrix (DEC's Unix) license for up to two users. Software includes TCP/IP, NFS, a C compiler, and DECwindows/X Window System programming tools and applications.

The systems can hold two internal 104-megabyte SCSI hard disk drives. DEC provides SoftPC DOS-emulation software for running DOS applications.

Price: With monochrome monitor, $7950; with color monitor, $11,450.
Contact: Digital Equipment Corp., 146 Main St., Maynard, MA 01754, (508) 493-5111.
Inquiry 1134.

Back to the Basics with the HeadStart Explorer

The Explorer is for people who want to learn about computers but are reluctant to take the first step.

It's based on a 4.77-/9.54-MHz 8088 microprocessor and comes with 512K bytes of RAM (expandable to 768K bytes), one 720K-byte 3½-inch floppy disk drive, and a 40-megabyte hard disk drive. There's an attached 84-key keyboard. Built-in software includes DOS 3.4, a word processor, a calculator, a datebook, and an address book. The monitor is optional.

Price: $599.
Contact: HeadStart Technologies Co., 40 Cutter Mill Rd., Suite 438, Great Neck, NY 11021, (516) 482-4255.
Inquiry 1133.

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

Switchable CPUs and a Small Footprint, Too

The small-footprint desktop CompuStar II comes with your choice of interchangeable CPU modules in the Wells American tradition of the original tower-based CompuStar.

You can transform your CompuStar II from a 20-MHz 80286 Model 220 to a 33-MHz 80386 Model 333 simply by changing the CPU module. You can also make it a 16-MHz 80386SX, a 20-MHz 80386, or a 25-MHz 80386.

The basic chassis measures 16 by 16 by 4 inches and comes with ports for a keyboard, a modem, a serial connection, and a parallel connection. The basic system also includes a 101-key firm- or soft-touch keyboard. Inside, you'll find a 200-W power supply, a motherboard (minus the CPU), six 16-bit slots (one for the CPU module), snap-mount connectors for up to 8 megabytes of RAM, a disk controller with cabling, and a hard disk drive interface.

There's room for a 3½-inch hard disk drive, mounted vertically to the right of where you'll find three 5¼-inch slots. CompuStar II options include a 40-, 100-, or 200-megabyte hard disk drive.

Price: Chassis, $750; Model 220/40 with 42-megabyte hard disk drive and monochrome monitor, $2765; Model 333/100 with 104-megabyte hard disk drive and VGA color monitor, $6655.
Contact: Wells American, 3243 Sunset Blvd., West Columbia, SC 29169, (803) 796-7800.
Inquiry 1132.

continued

NEC Grasps More Graphics

The new graphics monitors from NEC include two analog color monitors, the MultiSync 4D and 5D, and a monitor for text-based applications such as desktop publishing.

The 4D has a 15-inch (diagonal) screen and supports VGA, SuperVGA, 8514/A (1024 by 768 pixels interlaced), 1024 by 768 pixels noninterlaced, and Apple Macintosh II graphics standards. The dot pitch is 0.28 mm. Variable horizontal scan rates range from 30 to 57 kHz, and vertical rates range from 50 to 90 Hz. The number of possible colors is determined by the graphics board you use.

The MultiSync 5D is a 19-inch display that adds support for 1280- by 1024-pixel (noninterlaced) graphics to those listed above for the 4D. The dot pitch is 0.31 mm. The monitor offers horizontal scan rates of up to 66 kHz. Like the 4D, it incorporates a microprocessor-based digital control system that NEC says "automatically scans the incoming video signal and adjusts the screen parameters to show the optimum image."

The third monitor is a 13-inch gray-scale unit called the MultiSync GS2A. The analog GS2A has a paper-white phosphor screen, offers virtually unlimited shades of gray (the maximum is determined by the graphics board), and supports VGA, SuperVGA, and Apple Mac II graphics standards (up to 800- by 600-pixel resolution).

Price: 4D, $1799; 5D, $3699; GS2A, $349.
Contact: NEC Home Electronics (U.S.A.), Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
Inquiry 1137.

NEC's MultiSync 5D supports a variety of graphics modes, including VGA, SuperVGA, 8514/A, and Apple Mac II standards.

Seiko Enters Mac Market with New Color Printer

Seiko Instruments has announced a version of its CH-5500 color thermal printer for the Macintosh.

The QD5500 series includes a QuickDraw device driver that supports a set of 35 scalable outline fonts, similar in concept (but not identical) to the fonts that Apple will supply with System 7.0.

The printer offers 300-dpi resolution and comes in two sizes—8½ by 11 inches and 11 by 17 inches. It features a roll feed with an automatic cutter, which allows for a larger print area, Seiko says.

The 8½- by 11-inch printer includes 1 or 3 megabytes of RAM. The 3-megabyte version improves performance because you can access the entire color image in one pass through memory.

Price: 8½- by 11-inch printer with 1 megabyte of RAM, $7000.
Contact: Seiko Instruments USA, 1130 Ringwood Court, San Jose, CA 95131, (408) 943-9100.
Inquiry 1138.

A Half Gigabyte in a Half-Height Drive

Imprimis Technology's Wren VI is a SCSI-, ESDI-, or ST-506-based 502-megabyte hard disk drive that fits in a half-height 5¼-inch slot.

Data transfer is rated at 15 to 21 MHz, and the average seek time is 16 ms. The company claims that it can pack so much information in so little space because of its patented Zone Bit Recording method (also known as Constant Density Recording), which varies the frequency ranges of disk writing from the inside of the disk to the outside for optimum performance.

Imprimis also uses a "look-ahead buffer" with 32K bytes of RAM.

Price: $3200.
Contact: Imprimis Technology, Inc., 12501 Whitewater Dr., Minnetonka, MN 55343, (800) 828-8001, ext. 82.
Inquiry 1136.

A Large-Screen Monitor with a Budget Price

The MegaScreen Rival is a two-page, 19-inch monochrome display system for your Macintosh.

Features include 75-dpi, 1024- by 826-pixel resolution, a 75-Hz refresh rate, a paper-white phosphor display with darkened glass for glare reduction, and a built-in tilt-and-swivel stand. Each Rival system includes the monitor, add-in card, stand, and cables.

The MegaScreen monitor is 18 by 15 by 19 inches and weighs 46 pounds.

Price: For Mac SE, II, IIx, and IIcx, $1698; for Mac Plus, $1748.
Contact: MegaGraphics, Inc., 439 Calle San Pablo, Camarillo, CA 93010, (805) 484-3799.
Inquiry 1140.

Mac Drive Includes Five Types of Data Backup

The Silhouette Mac RD-44 is a removable SCSI-based Macintosh hard disk drive with a 25-ms access time and 44-megabyte disk cartridges.

The included software has five backup modes: shadow, periodic incremental, file-by-file, time-of-day, and mirror image. The drive comes with one cartridge.

Price: $1595; extra cartridges, $149.
Contact: Cumulus Corp., 23500 Mercantile Rd., Cleveland, OH 44122, (216) 464-2211.
Inquiry 1139.

continued

After centuries of practice, mankind perfects engineering calculations: MathCAD.

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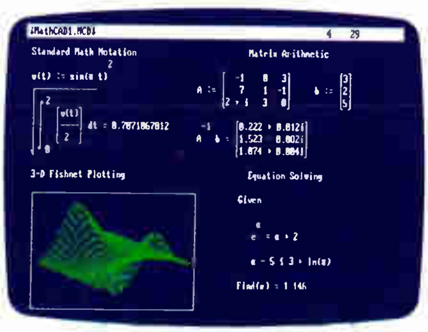

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March 14, 1989 issue.
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Best of '87

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PE #3

Circle 165 on Reader Service Card

HARDWARE • ADD-INS

Inexpensive Real-Time TV for Your Macintosh

The MicroTV II is a low-priced NuBus card that displays real-time TV (or any other video source) in 128 levels of gray on a Mac II equipped with an 8-bit color card and color monitor.

The video appears in your window, complete with a refresh rate of one-thirtieth of a second. It makes your window look like a black-and-white TV, complete with "knobs" for channel, volume, contrast selection, and an on/off switch. Software also lets you copy and paste.

The board is cable-ready, so you can plug the coaxial cabling from your local cable TV franchise directly into the back of the card. Then the 108-channel tuner takes over, manipulating composite and direct audio/video inputs.

To extend the software that makes use of the card, a developer's toolkit contains HyperCard and SuperCard external commands, interfaces for popular development systems, technical information, sample applications with source code, and MacApp object libraries.

Price: $395.
Contact: Aapps Corp., 110 Pioneer Way, Mountain View, CA 94041, (415) 961-4033.
Inquiry 1141.

Triple the Speed of the Mac II and IIx

DayStar Digital plans to speed up your Mac's CPU, bus, RAM access, video performance, and SCSI-peripheral-based performance with a line of add-in boards.

To do this, the company is starting with a line of accelerator cards (for CPU speeds up to five times faster) and is introducing a proprietary bus alternative that speeds up bus transfers by a factor of three. To run on the proprietary bus or to default to the slower NuBus, DayStar Digital's new RAM card doubles accessible RAM. The company is also developing video and SCSI cards with NuBus and proprietary bus interfaces. Now in beta testing, they are scheduled to be delivered before the year's end.

The Accelerator II and the Accelerator IIx (for the Mac II and IIx) are based on Motorola's 68030 microprocessor. They feature speeds of 25, 33, 40, and 50 MHz and attain zero-wait-state performance by incorporating a 32K-byte cache with 15-ns static RAM. A Motorola 40-MHz 68882 math coprocessor is an option with each accelerator.

To eliminate the NuBus bottleneck, DayStar Digital's Extended CPU Interface (XCI) backplane card features 33-MHz performance and three proprietary slots. (An XCI is included with every accelerator board you purchase.) The RAM card, with a proprietary port and a default port for NuBus, features 100-ns RAM, expandable to 16 megabytes.

Inside your Mac, the CPU accelerator board fits horizontally above the motherboard and doesn't use any of your six NuBus slots. The XCI backplane is a half-width card that fits across the front of your system and plugs into both the accelerator card and the front ends of the proprietary RAM card (and the video and SCSI cards, when they're available).

Price: 25/030 Accelerator II/IIx, $2995; 33/030, $4995; 40/030, $5995; 50/030, $6995.
Contact: DayStar Digital, 5556 Atlanta Hwy., Flowery Branch, GA 30542, (404) 967-2077.
Inquiry 1144.

Put a Padlock on Unpaid Computers

One of the continuing problems for computer dealers who rent or lease systems is what to do if clients don't make their payments. Collecting money or repossessing systems can be risky business.

Genesys has come up with a singular solution to the problem. Its uniquely named and uniquely featured Click/Clock is an add-in card for IBM PCs and compatibles.

It automatically locks up a system if a payment hasn't been received by a specific date that is programmed into the card.

Click/Clock operates independently of both DOS and the existing hardware, and it even has a tamper-resistant lock so that it can't be removed from the system. Since the computer is completely unusable once Click/Clock locks it up, you can use the customer's own data as collateral.

Price: $249.
Contact: Genesys, 2301 Lucien Way, Suite 105, Maitland, FL 32751, (407) 875-0101.
Inquiry 1143.

HARDWARE • OTHER

A Long and Happy Life for Your AT Battery

If you've ever had your IBM AT's battery suddenly die, you know that once the CMOS that stores your system parameters loses data, your computer is virtually useless. A dead battery causes loss of time/date, loss of drive setup data, and mysterious software and hardware errors. The lithium batteries that most ATs use are normally good for a year or two, but they are often difficult to purchase and a challenge to replace.

With its bATPac, Rupp Corp. offers the first rechargeable backup battery for ATs and compatibles.

The bATPac is a sealed rechargeable battery with an expected lifetime of at least 10 years, which will make it last long after your computer has become completely obsolete. It continually charges while the system is on and can keep the CMOS happy for at least a year of power-down.

The unit measures 2⅜ by 2⅜ by 1 inch. You install it by plugging it into your AT's internal battery connector. The battery is charged using power from a disk drive power connector. It includes a Y-connector, along with a Velcro attachment for securing the bATPac to the side of your system's power supply.

Price: $39.95.
Contact: Rupp Corp., 835 Madison Ave., New York, NY 10021, (212) 517-7775.
Inquiry 1145.

continued

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Multiple database access	✓	
Referential integrity	✓	
Automatic recovery	✓	
Record & File locking	✓	
RAM resident		✓
db_QUERY 2.1 SQL-based Query:		
Relational Query & Report Writer	✓	
db_REVISE 1.0 Database Restructure Program:		
Total database redesign/restructuring	✓	
Operating Systems*: VMS, ULTRIX, UNIX	✓	
BSD 4.2, SunOS, XENIX, MS-DOS,	✓	
Macintosh and MS Windows, OS/2 compatible	✓	
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C++ compatible	✓	
LANs*: 3COM, Novell, Banyan, AppleShare	✓	
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Read & Write WKS, WK1 & DBF files	✓	
SOURCE CODE AVAILABLE:	✓	
ROYALTIES: (Absolutely not!)		✓✓

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1 cup coarsely chopped
2 eggs
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LOGITECH
Lift off.
Let her roll.
Give them a piece of your mind.
Off the wall.
See lion.
Make amends.
COMMERCIAL LEASE
check on this
change name

Voice I Translates from English to Spanish

The Voice I system is a small microprocessor-based system that translates spoken English into Spanish, Advanced Products claims. It's built on a proprietary platform with one 8-bit and two 16-bit microprocessors, and it uses a proprietary operating system.

Although it will operate as a stand-alone unit, it also includes an RS-232C port for personal computer connection.

The Voice I is primarily designed to translate from English to other languages with specially designed cassette-size modules. The English to Spanish module can translate more than 35,000 phrases, the company claims.

A second module, scheduled to ship this month, will translate spoken English into French. There's also the Voice Assistant module, a personal information manager (with calendar, daily scheduler, phone list, and search capabilities) based on voice recognition and natural-language processing.

With a translation module, the 3-pound, 8- by 7- by 3-inch hand-held unit translates phrases almost instantly. But you have to speak slowly, word by word. Your words are also displayed on the 160- by 128-pixel LCD. The Voice I will work if the input rate is below 60 words per minute.

The basic system includes 4 megabytes of addressable memory. There's also an internal microphone and a speaker, a microphone jack for an external microphone and headset, an external speaker connector, a rechargeable battery, and an AC power adapter.

When you say, "I don't speak Spanish," the Voice I says, "No hablo Español."

Price: $2000; Voice Assistant module, $300; English to Spanish module, $300.
Contact: Advanced Products & Technologies, Inc., 15444 Northeast 95th St., Redmond, WA 98052, (206) 883-8297.
Inquiry 1147.

And the Word Became Code

Franklin Computer's Electronic Holy Bible includes a microprocessor, 1 megabyte of ROM, a tactile-feedback QWERTY keyboard, a supertwist LCD, and word processing–style software. It is available in both King James and Revised Standard versions.

The NEC V20 microprocessor allows the Bible-size, notebook-computer-styled device to almost instantaneously find specific text. If you don't know the exact spelling of the word on which you're doing a search, you can approximate the word phonetically.

The screen always displays the names of books of the Bible, which you can select with the cursor and access by pressing Return. Above the icons is room for four lines of type, with nearly 40 characters in each line. Each character cell has a resolution of 5 by 8 pixels.

Price: $299.
Contact: Franklin Computer, 122 Burrs Rd., Mt. Holly, NJ 08060, (609) 261-4800.
Inquiry 1148.

HP's Spectrum Analyzers Designed Around PCs

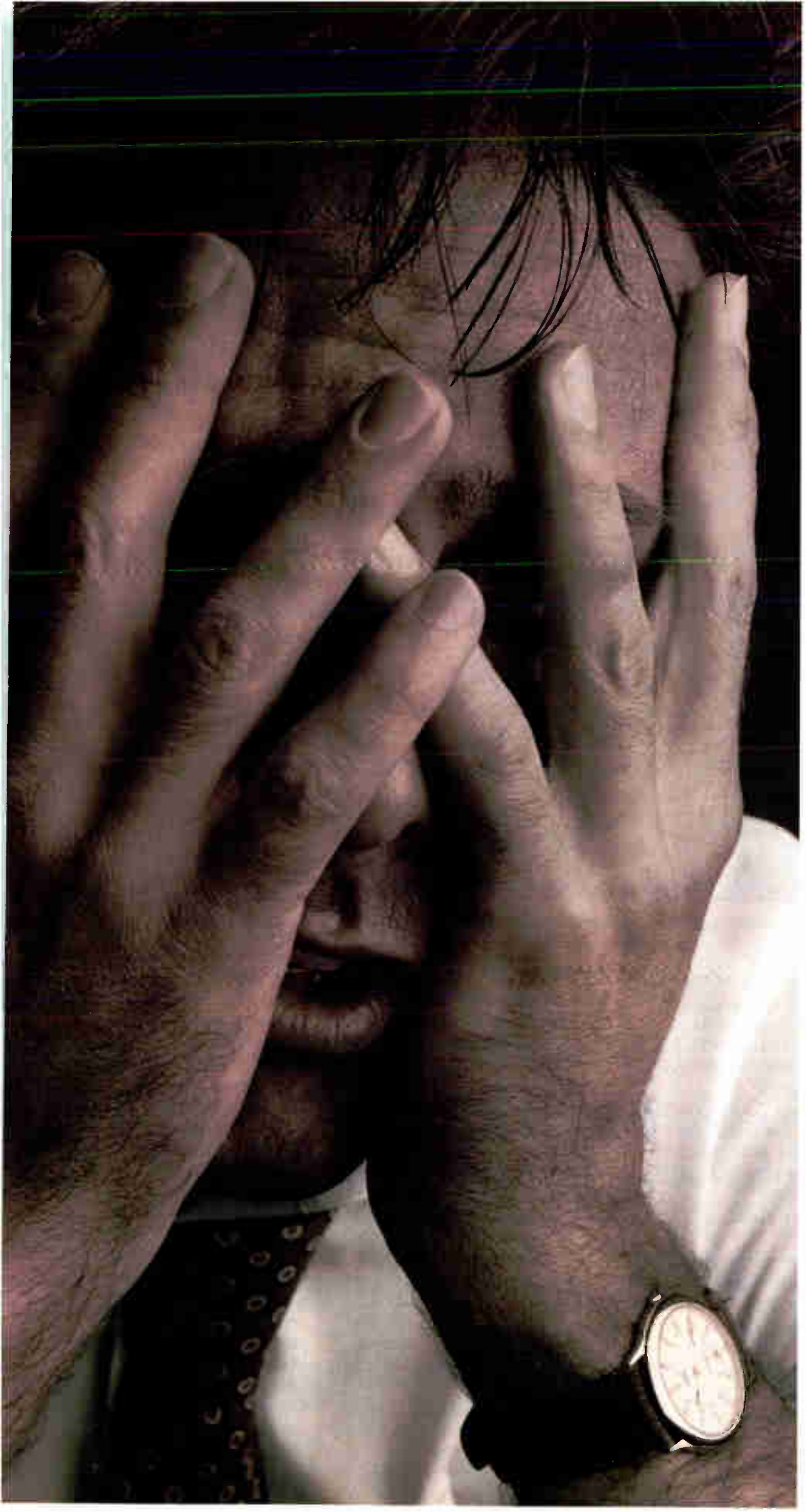
Hewlett-Packard's two new spectrum analyzers are PC-based instruments designed to help engineers solve mechanical-test, production-test, and signal characterization problems. Specifically, they measure frequency response functions, auto/cross correlation, transient-time capture, one-third octave with A-weighting, stimulus-response testing, and order tracking.

The two models, the HP 3567A and the 3566A, feature two and six channels, respectively.

You need at least a DOS-based 80286 machine running Microsoft Windows with EGA graphics. Each analyzer comes with a software driver, and you connect the fast Fourier transform module on the spectrum analyzer through cabling to your computer's serial port.

The software lets you manipulate up to 16 channels of incoming data, eight on-screen at a time. For measurement automation, you can access every automation feature by programs written in a variety of Microsoft-supported programming languages.
Price: HP 3567A, $18,000; HP 3566A, $22,000.
Contact: Hewlett-Packard Co. Inquiries, 19310 Pruneridge Ave., Cupertino, CA 95014, (800) 752-0900.
Inquiry 1146.

continued



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Replace Cabling Headaches with Radio or Light

While there are few new choices in LAN cabling, there are now two cable-less networking solutions. Telesystems SLW has a cellular radio solution for NetWare-based LANs, and Photonics has an infrared-based LocalTalk-compatible transceiver.

The ARLAN 450 card plugs into any IBM PC or compatible and runs under Novell NetWare. The wireless two-thirds-length card uses cellular radio frequencies for 230-kbps data transmission rates. It's an 8-bit bus-based version of Telesystems' serial product.

Telesystems recommends that you use an ARLAN 450 (which has a built-in transceiver) at each of the nodes, and an ARLAN 440 and its separate transceiver, Model 010, at your file server. The 450 is the equivalent of the 440 with the 010, but by separating the transceiver, you don't have to locate your file server in the physical middle of the nodes. Both boards include NetWare drivers.

You use unshielded or shielded twisted-pair cable between the 440 in the file server and the brick-size 010 transceiver. Distance is limited to less than 2000 feet.

In an office environment with physical barriers, Telesystems recommends that you link no more than 10 450-based PCs in a radius of no more than 250 feet from the file server. In an open factory, the radius recommendation is 1500 feet. Or you can use the transceivers as bridges, as long as there's a clear line of sight, for transmission distances of up to 6 miles.

Using "spread spectrum" radio technology with radio output power of 1 W, there's no need for an FCC license to use the ARLAN card, Telesystems reports.

Price: ARLAN 450, $1500; ARLAN 440, $500; ARLAN 010, $2000.

Contact: Telesystems SLW, Inc., 85 Scarsdale Rd., Suite 201, Don Mills, Ontario, Canada M3B 2R2, (416) 441-9966.

Inquiry 1149.

Each Photolink transceiver replaces a strand of LocalTalk cabling.

Meanwhile, Photolink uses beams of invisible infrared light, reflected off the ceiling, to communicate between Macintosh computers. Photonics says that replacing cables with infrared light increases flexibility, lowers costs, and even improves security. The company is also working on a version that provides serial communications between terminals and hosts.

A Photolink installation consists of individual transceiver units mounted on top of office partitions and pointing toward a common spot on the ceiling. Each wedge-shaped unit, about the size of a telephone, can support up to four Macs, which plug in via phone cables connected to the LocalTalk network port.

Photolink is effective in an unobstructed area of roughly 70 feet in diameter, the company says. The ceiling does not have to be specially prepared; Photonics says the system will work on everything from acoustical tile to dark oak beams.

AppleTalk networks run at about 230 kbps, as does Photolink, although Photonics claims that the current units are capable of running at 1 Mbps. The company plans a 4-Mbps Token Ring model for 1990 and a 10-Mbps Ethernet version for 1991.

Price: Transceiver, $995.

Contact: Photonics Corp., 200 East Hacienda Ave., Campbell, CA 95008, (408) 370-3033.

Inquiry 1150.

Ready, Set, Network

ReadyNet might be for you if you want a simple, low-cost LAN for your home or small business. It's an unshielded twisted-pair-based (telephone wiring), bus-based network with XT- and AT-compatible adapter boards and CSMA collision avoidance. The data rate is 1 Mbps.

The start-up kit includes two boards, 50 feet of cabling with RJ-11 connectors on each end, and software drivers that configure the two-node basic network. You purchase each add-on node in a kit that includes a separate card, cabling, and a software driver. The primary server requires 184K bytes of RAM; each node requires 60K bytes.

ReadyNet has an automatic preconfigured connection feature and provides basic functions, such as messaging, file transfer, and printer spooling. There's also a remote-control "virtual console" function that lets one person at one ReadyNet PC control another person's application.

ReadyNet supports up to 24 PCs at distances of up to 1000 feet from the primary server. The network operating system was designed for this network and is therefore proprietary.

Price: Start-up kit, $499; each add-on, $249.

Contact: Corvus Systems, Inc., 160 Great Oaks Blvd., San Jose, CA 95119, (408) 281-4100.

Inquiry 1152.

continued

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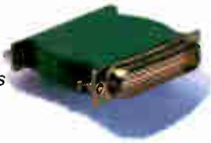

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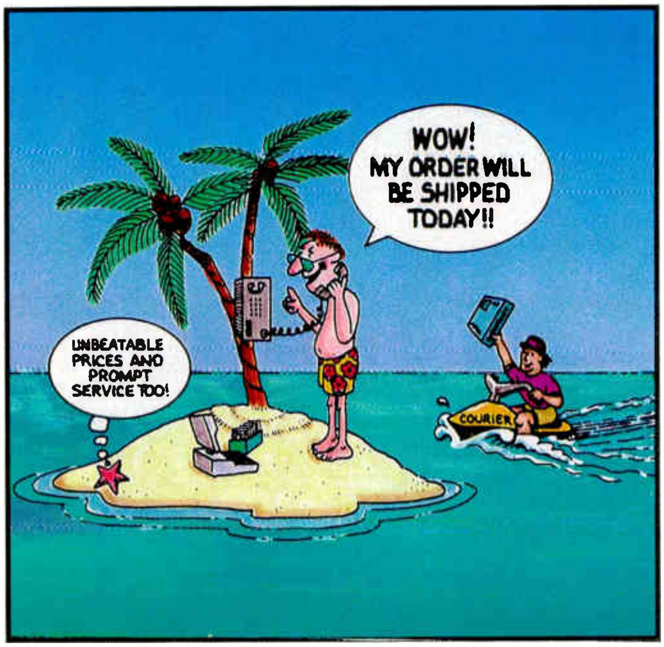

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VMOS/3	99	89

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QuickBASIC	99	69
Quick-Comm	139	125
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Microsoft C	450	299
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MS QuickC w/ Mouse	199	99
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Turbo C	150	105
Turbo C Professional	250	175
WATCOM C 7.0	395	319
Zortech C	90	79

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C-ISAM	225	209
Codebase IV	295	219
c-tree	395	318
d-tree	495	395
r-tree	295	241
CQL	225	199
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Essential B-Tree	99	89
pBase	149	135
XQL	795	599
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Greenleaf Functions	229	165
Greenleaf SuperFunctions	299	209
Turbo C TOOLS/2.0	149	115

C SCREENS

	LIST	OURS
C-Worthy w/ forms and source	495	CALL
Facelt	99	89
Greenleaf DataWindows	395	279
JAM	595	529
Panel Plus	495	395
Vermont Views	395	CALL
w/ source code	790	CALL
Vitamin C	225	165
VC Screen	149	125
Vlib	149	129

C-SOURCE ANALYSIS

	LIST	OURS
AutoFlow-C	299	269
C/Analyst	150	135
Clear +	200	169
C:Lines/C:Tree	80	75
Codan	395	359

C-UTILITIES/OTHER

	LIST	OURS
Code Master v. 2	289	259
Csource	395	359
C-Terp	300	219
Heap Expander	80	70
JAKE	495	429
Norton Guides for C	100	65
PC-lint	139	105
PRO-C	675	569
TimeSlicer	295	279
w/source	1000	899
Vmem/C	189	169

COBOL LANGUAGE

	LIST	OURS
Micro Focus:		
COBOL/2 w/ Toolset	1800	1499
COBOL/2 Toolset	900	749
Personal COBOL	149	129
MS COBOL	900	629
Realia COBOL	995	849
w/ RealMENU	1145	979
SCREENIO	400	375

DATABASE DEVELOPMENT

	LIST	OURS
Clarion 2.0	695	499
Clipper 5.0	695	439
dBASE IV	795	489
dGE	195	179
FoxBASE+	395	249
Magic PC	299	249
Paradox 3.0	725	509
R&R Report Writer	150	129
w/ Clipper/ FoxBASE module	200	159
R&R Code Generator	150	129
SilverComm Library 2.0	189	165
Tom Rettig's Library	100	80

DEBUGGERS

	LIST	OURS
386 DEBUG	195	159
Multiscope	299	CALL
Periscope II-X	145	105
Periscope IV/16 MHz	1995	1849
Periscope IV/20 MHz	2295	1995
Periscope IV/25 MHz	2595	2295
Sherlock	195	179
Soft Probe II/TX	395	345
VM Debug	99	89

EDITORS

	LIST	OURS
BRIEF	195	CALL
Epsilon	195	159
KEDIT 4.0	150	125
MKS Vi	149	129
Norton Editor	75	59
SLICK Editor	195	175
SPF/PC	245	199
VEDIT	69	59
VEDIT PLUS	185	115

FORTRAN LANGUAGE

	LIST	OURS
Grafmatic	135	119
Lahey F77L	595	529
Lahey Personal FORTRAN 77	95	89
MS FORTRAN	450	299
Plotmatic	135	119
Printmatic	135	119
RM/FORTRAN	595	499

GRAPHICS LIBRARIES

	LIST	OURS
Baby Driver	250	225
Essential Graphics	299	239
Font-Tools	150	135
Graf-Text	89	79
GraphiC 5.0	395	322
Graphics-MENU	195	175
GSS Graphics Devel. Toolkit	595	509
HALO	395	279
HALO Window Toolkit	595	419
Icon-Tools/Plus	150	135
MetaWindow	195	159
FontWindow	95	85
Menuet	250	225
PCX Effects	99	89
PCX Programmer's Toolkit	195	175
PCX Text	99	89
XVT	595	509

LANGUAGE DEVELOPERS

	LIST	OURS
LALR	99	90
MKS LEX & YACC	249	209
PCYACC Professional	395	359

LINKERS/LIBRARIANS

	LIST	OURS
Plink86plus	495	419
PolyLibrarian II	149	135
.RTLink	195	185

MODULA-2

	LIST	OURS
LOGITECH Modula-2:		
Compiler Pack	99	75
Development System	249	199
Repertoire	149	135
Solid B+ Toolkit	100	90
TopSpeed Modula-2:		
B-Tree Toolkit	80	72
Communications Toolkit	80	72
Compiler Kit	100	89
DOS 3-Pack	200	179
TechKit	60	55
VID	60	55

OS/2 TOOLS

	LIST	OURS
Brief	195	CALL
Btrieve	595	459
Greenleaf DataWindows	395	309
HALO	695	489
MKS RCS	395	335
MKS Toolkit V3.1	495	419
MS OS/2 Present. Mgr. Toolkit	500	349
MS OS/2 Present. Mgr. Softset	150	105
Paradox OS/2	725	543
Topspeed Modula-2	195	179
Vitamin C	345	279

PASCAL LANGUAGE

	LIST	OURS
Asynch PLUS	149	115
B-tree Filer	125	99
MS QuickPASCAL	99	69
Object Professional	150	119
Power Screen 1.1	149	115
Power Tools PLUS/5.0	149	115
Turbo Analyst	99	79
TurboMAGIC	199	179
Turbo Pascal 5.5	150	99
Turbo Pascal 5.5 Professional	250	169
Turbo-Plus 5.5	150	129
Turbo Professional 5.0	125	99

PROTOTYPING

	LIST	OURS
Dan Bricklin's Demo II	195	179
Instant Replay III	150	135
Show Partner F/X	350	319

SMALLTALK LANGUAGE

	LIST	OURS
Smalltalk-80 (386)	595	535
Smalltalk/V	100	85
Goodies Libraries	50	45
Smalltalk/V 286	200	169
Smalltalk/V PM	CALL	CALL

UTILITIES

	LIST	OURS
1 DIR Plus	95	75
Copy II PC	40	35
Copy II PC Option Board	159	139
Disk Technician Advanced	190	159
Disk Technician Plus	130	109
Dr. Switch	60	55
Fast!	99	89
FASTBACK Plus	189	159
hTest:hFormat	90	80
Lotus Magellan	195	CALL
MACE GOLD	149	129
MKS Toolkit	249	209
Norton Utilities	100	65
Norton Utilities Advanced	150	105
PC Fullback	70	59
PC/Tools Deluxe	129	89
Spinrite	59	49
Vfeature Deluxe	120	109
V OPT	60	55
XENOCOPY-PC	80	70
XTreePro	129	109

VERSION CONTROL SYS.

	LIST	OURS
MKS Make	149	129
MKS RCS	189	159
Personal PVCS	149	125
PolyMake	149	125
Professional PVCS	395	335
Seidl Version Manager	300	269
TLIB	100	90
5 Station LAN	300	259

WINDOWS (MS) TOOLS

	LIST	OURS
Actor	495	429
Case:W	795	759
C-Talk/Views	450	375
dBFast/Windows	249	229
MS Windows Development Kit	500	349
Whitewater Resource Toolkit	195	169
WinTrieve	395	339

NEW RELEASES

WinTrieve™
Microsoft® Windows-based file management system for application programmers using C or Actor. WinTrieve efficiently manages large amounts of information by storing data records on disk in indexed sequential access method (ISAM) files.
List: $395 **Ours: $339**

MKS TOOLKIT V3.1
Excellent for learning UNIX! New 260 page *users guide* includes an overview to introduce novices to general commands. Contains full MKS AWK, KornShell and Vi tutorials. New *install* and *config* programs make it easy to set up the configuration that best suits your needs. 15 new utilities added.
List: $249 **Ours: $209**

SMALLTALK/V PM
Combines the power of the industry's leading object-oriented environment with the richness of Presentation Manager. Fully compiled, giving a PM application developer an extremely responsive environment with which to work. Source code compatibility with Digitalk's other Smalltalk products.
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Special of the Month:
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The ***Novell C Network Compiler*** gives you a direct link into NetWare, the leading network operating system with the world's largest installed base of network application users.

Order the C Network Compiler from Programmer's Paradise before October 29 and save $95 on the purchase of any other software that we carry!

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Baler Spreadsheet Compiler	495	459
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Matrix Layout	150	129
muLISP-87 Interpreter	300	219
Opt-Tech Sort	149	129
Paginate	100	89
PC/Forth +	250	225
PC Metric	199	185
PC Scheme	95	79
Personal Rexx	150	129
Source Print	99	89
Tree Diagrammer	99	89
UNIX SOFTWARE		
Aspen Korn Shell	145	109
Basmark QuickBASIC	695	629
Epsilon	195	159
Interactive 386/IX	1095	989
PRO-C	1835	1559
SCO XENIX 386 Complete Sys.	1595	1355
for PS/2	1695	1439
SCO XENIX 386 Oper. Sys.	695	589
Terminal Control	995	879
VPIX 386 Unlimited	995	845
BLAISE		
Asynch Plus	149	115
C Asynch Manager 3.0	189	139
C Tools Plus/ 6.0	149	109
Exec	95	75
KeyPilot	50	39
Power Screen 1.1	149	115
Power Search	149	115
Power Tools Plus/ 5.0	149	115
Turbo C Tools/ 2.0	149	115
BORLAND		
Paradox 3.0	725	509
SideKick Plus	200	139
Sprint	200	139
Turbo Assembler/Debugger	150	105
Turbo Basic	100	69
Turbo C 2.0	150	105
Turbo C 2.0 Professional	250	175
Turbo Pascal 5.0	150	99
Turbo Pascal 5.0 Professional	250	169
Turbo Prolog	150	105
Turbo Prolog Toolbox	100	69
GREENLEAF		
Greenleaf Bus. MathLib	395	279
Greenleaf Comm. Library	299	209
Greenleaf DataWindows	395	279
Greenleaf Functions	229	165
Greenleaf MakeForm	125	95
Greenleaf SuperFunctions	299	209
Greenleaf ViewComm	559	475
MEDIA CYBERNETICS		
Dr. HALO III	140	101
HALO	395	279
HALO for MS Developers	595	419
HALO for OS/2	695	489
HALO for two languages	545	389
HALO Programmer's Workbook	80	59
HALO Window Toolkit	595	419
MICROSOFT		
MS BASIC/6.0	295	209
MS C	450	299
MS COBOL	900	629
MS Excel	495	299
MS FORTRAN	450	299
MS Macro Assembler	150	105
MS Mouse Bus or Serial		
w/ EasyCAD	175	125
w/ Paintbrush & Mouse Menus	150	105
w/ Paintbrush & Windows	200	139
MS OS/2 Present. Mgr. Toolkit	500	349
MS OS/2 Softset	150	105
MS Pascal	300	209
MS QuickBASIC 4.5	99	69
MS QuickC 2.0	99	69

	LIST	OURS
MS QuickPASCAL	99	69
MS Sort	195	139
MS Windows	99	69
MS Windows/386	195	136
MS Windows Development Kit	500	349
MS Word 5.0	450	285
MORTICE KERN SYSTEMS		
MKS Awk	99	85
MKS Lex and Yacc	249	209
MKS Make	149	129
MKS Make for OS/2	249	209
MKS Programming Platform	665	565
MKS RCS	189	159
MKS RCS for OS/2	395	335
MKS SoftQuad Publishing Sys.	495	469
MKS Software Mgmt. Team	299	255
MKS Toolkit V3.1	249	209
MKS Toolkit V3.1 for OS/2	495	419
MKS Vi	149	129
MKS Vi for OS/2	199	169
NOVELL		
Btrieve Single-User	245	185
Btrieve for DOS 3.1 Networks	595	459
Btrieve for OS/2	595	459
Btrieve for XENIX	595	459
C Network Compiler	695	559
C Network 386 Compiler	995	799
NetWare C Interface for DOS	295	239
NetWare MHS	100	79
NetWare MHS Interface Guide	145	129
NetWare RPC	950	759
NetWare RPC for OS/2	1750	1399
NetWare SQL	595	459
NetWare System Calls for DOS	195	159
XQL	795	599
Xtrieve PLUS	595	459
Xtrieve PLUS for OS/2	595	459
POLYTRON		
Personal PVCS	149	125
Plink86plus	495	419
PolyAWK	99	85
PolyDoc	199	169
PolyLibrarian	99	85
PolyMake	149	125
PolyXRef	99	85
Professional PVCS	395	335
RAIMA		
db_FILE Bundle (Single User)	595	509
db_FILE Bundle (Multi-User)	295	249
WKS Library	195	165
SOUTH MOUNTAIN		
Breakout-II	125	99
C Utility Library	199	159
Essential B-Tree (w/ source)	99	79
Essential Communications 3.0	249	199
Essential Graphics	299	239
Hold Everything (w/ source)	129	109
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ScreenStar (w/ source)	198	159
WHITEWATER GROUP		
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WinTrieve	395	339

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Return Policy
30-day no-hassle return policy. Some manufacturer's products cannot be returned once disk seals are broken.

Turbo Pascal 5.5

Borland's Turbo Pascal, the world-standard Pascal compiler with more than one million copies in use, has added object-oriented programming to its newest release, version 5.5. Borland combined the simplicity of Apples's Object Pascal language with the power and efficiency of C++ to create Turbo Pascal 5.5. With Turbo Pascal objects, your code will be compact, flexible and reusable. And it will be easier to extend and maintain.

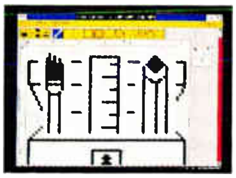
BORLAND

Turbo Pascal 5.5: $99
Turbo Pascal Professional 5.5 (with Turbo Debugger): $169

Whitewater Resource Toolkit™

The ***Whitewater Resource Toolkit*** is a new on-screen editor for creating and managing Windows resources such as menus and dialog boxes. Application developers and system integrators use the ***Whitewater Resource Toolkit*** for designing or customizing an application's look and feel.

Microsoft® Windows Resource Editor–NEW!
Special Price: $169



The Whitewater Group®

The toolkit is an integrated set of seven interactive editors to create dialog boxes, menus, color bitmaps, cursors, icons, strings and accelerators.

With it, you can manage resources for any new or existing Windows program written in C or Actor. The Windows SDK and resource compiler are not required.

C TOOLS PLUS/6.0
New from Blaise Computing

Filled with many advanced routines for developing high-powered Microsoft C applications, including: virtual, stackable menus and windows with full mouse support; multiple virtual pop-up help screens; functions for writing interrupt service routines, creating pop-up memory resident applications, and much more.

C TOOLS PLUS includes all source code, complete sample programs, and an online database compatible with the QuickC Advisor.

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Outfit Your PC for ISDN

If you're an IBM PC user who wants ISDN capabilities, the PC² is an economical board/software package that provides full 144-kbps connectivity through all three ISDN channels.

Like most other ISDN products for personal computers, it's compatible only with AT&T's 5ESS central office computer switch. For simultaneous voice and data, it uses a coprocessor, an 80C188, and TSR software on top of DOS. Memory requirements are 242K bytes with standard RAM.

PC² features seven applications, including an optional Screen Share package that lets two people simultaneously work on the same PC application from two different locations.

The Vadis system software provides ISDN connectivity through the built-in transparent DOS- or NetBIOS-based remote file access/file sharing system or through the on-board serial port emulation, with or without an AT modem command-set interpreter.

The Voice Call Manager initially helps you place a voice-based call to anyone on your phone list database. It also gives you a help screen for all 64 ISDN telephone voice features.

The Data Call Manager helps you place a data-only call to another ISDN device, with up to 16 "terminal profiles" selectable by name, and it lets you perform a file transfer in the background. It also lets you talk to others through an interactive conferencing system.

An E-mail function lets you send and receive messages between PC² devices and through established public or host-based E-mail systems. The Desktop Calendar is similar to most calendars in personal information management software, including an audible signal for reminders.

The Script Processing function gives you information on the people calling you before you pick up the phone, but only if they're on another PC² device.

Price: $1180; Screen Share, $125.

Contact: Vadis, Inc., 2201 Waterview Pkwy., Suite 1200, Richardson, TX 75080, (214) 690-2481.

Inquiry 1153.

PC² links up to seven ISDN applications to your phone and your DOS computer, including screen sharing.

LAN RAM Saver for NetWare

LANSpace, from Lan Systems, is a RAM saver for NetWare 286. It takes the NetWare drivers (Net3 or Net4) out of conventional memory and puts them into extended memory, saving 35K bytes of RAM.

LANSpace also allows you to load and unload NetBIOS without rebooting, for an additional savings of 21K bytes of RAM, the company claims.

Price: $495 per server.

Contact: LAN Systems, Inc., 599 Broadway, 11th Floor, New York, NY 10012, (800) 827-5267.

Inquiry 1151.

Crosstalk Now Appearing in Windows

Crosstalk, one of the most popular communications packages for the IBM PC, has moved over to Microsoft's Windows environment.

One of the main features of the program is its support of the Dynamic Data Exchange facility of Windows. This allows Crosstalk to import and export data easily to and from other Windows applications, such as Microsoft's Excel spreadsheet program. Digital Communications Associates reports that an Excel macro can automatically call a remote database, download a small list of stock prices, and graph the results.

Like other Windows packages, Crosstalk makes full use of pull-down menus and other user-friendly features. If you select a certain item from a menu with a mouse, Crosstalk will echo that item back to the host system.

The new Crosstalk is compatible with the script language of Crosstalk Mark IV.

Price: $195.

Contact: Digital Communications Associates, 1000 Holcomb Woods Pkwy., Suite 440, Roswell, GA 30076, (404) 998-3998.

Inquiry 1154.

Proteon Offers Unshielded Support for Token Rings

The company that introduced the first token-passing ring LAN in 1981 is now the first to ship unshielded twisted-pair wiring support for 4-, 10-, and 16-Mbps token-ring networks.

Support for 16-Mbps token ring over unshielded and shielded twisted-pair cabling lets Proteon take advantage of inexpensive, readily available wiring. Unshielded twisted-pair wiring is used by AT&T for Private Branch Exchange installations.

The key to Proteon's support for unshielded twisted-pair wiring is a new multi-access unit called the Series 70 Intelligent Wire Center. The p7202 modular hub supports the 4- and 16-Mbps data transmission rates afforded by IBM's 802.5-compliant Token Ring solution, as well as the 10-Mbps data rates supported by Proteon's eight-year-old proprietary networking hardware.

Electromagnetic interference problems, Proteon says, have been solved with passive filtering at both ends of the cable. Each multi-access unit supports a cabling distance of 279 feet.

If you prefer IBM's wiring scheme and shielded twisted-pair media, Proteon offers the Series 70 p7201 modular hub. For the same price as the p7202, it supports 4- and 16-Mbps token rings, but not Proteon's proprietary 10-Mbps token ring.

Price: $1295, not including token ring PC boards.

Contact: Proteon, Inc., Two Technology Dr., Westborough, MA 01581, (508) 898-2800.

Inquiry 1155.

continued

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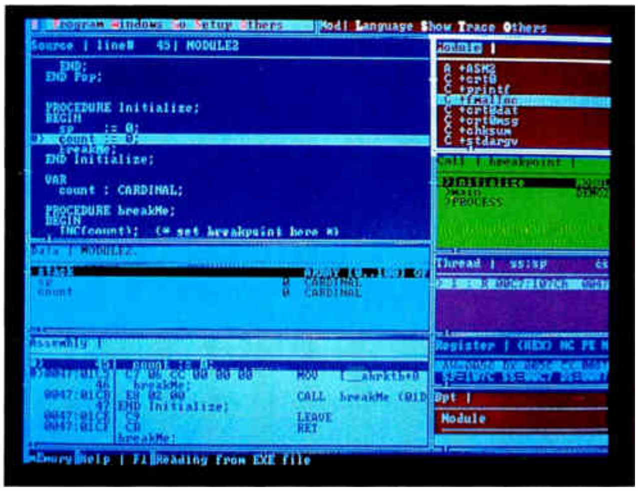
Circle 248 on Reader Service Card

Find the Bugs in OS/2 Code

Logitech's MultiScope Debugger is designed specifically for those of you attempting to cope with the slings and arrows of OS/2 development. It offers run-time and postmortem debugging options. The run-time debugger controls execution with a set of control features and stepping commands. The postmortem debugger captures the program execution state of an application running outside the debugger at the time of the crash. You can then examine the resulting dump file to find the program crash condition.

The debugger uses multiple overlapping windows to display up to 13 different program views simultaneously. You can create custom configurations of source, assembly, data, register, memory, module, breakpoint, watchpoint, graphical data, threads, call chain, log, and output views. MultiScope also includes complete support for debugging threads, dynamic link libraries, and child processes.

One of the program's unique features is a specialized data display that shows complex data structures in a graphical form. MultiScope is compatible with any language that generates standard CodeView OS/2 debugging information, including Logitech Modula OS/2, Microsoft C, and IBM C/2. It works in OS/2 text mode and under Presentation Manager.
Price: $299.
Contact: Logitech, Inc., 6505 Kaiser Dr., Fremont, CA 94555, (415) 795-8500.
Inquiry 1102.



Developed with OS/2 for OS/2, MultiScope works under Presentation Manager and in text mode.

Express C Compiler for OS/2, DOS

The TopSpeed C Professional Edition compilers automatically create dynamic link libraries and support Microsoft Windows and the OS/2 Presentation Manager. The Jensen & Partners International (JPI) compiler is based on an optimized code generator that lets you integrate routines from multiple languages into a single application.

The code generator automatically detects the type of source code in each window, calls the appropriate compiler, and links the routines. It provides a common run-time library and consistent memory allocation routines for all the JPI language implementations (currently, Modula II, C, and Assembler).

The Professional Editions include start-up assembler code, full source code to libraries, and a watch utility for viewing any selection of DOS calls.

The TopSpeed C compiler includes a Make facility that automatically updates and maintains file dependencies. It is fully ANSI-compatible. The company hopes to ship a C++ compiler early next year, and an Ada compiler is under development.
Price: Standard Edition (includes debugger and compiler), $199; DOS Professional Edition, $395; OS/2 Professional Edition, $495.
Contact: Jensen & Partners International, 1101 San Antonio Rd., Suite 301, Mountain View, CA 94043, (800) 543-5202 or (415) 967-3200.
Inquiry 1103.

Search Engine Zeros in on String Patterns

Blaise Computing says that Power Search, a library of C functions, uses a new technology to execute fast searches for strings or expressions in DOS- and OS/2-based applications. It generates and executes custom machine code that's optimized for a specific pattern.

Power Search matches both ordinary strings and regular characters. Strings can include metacharacters that represent common character classes, such as digits or lowercase letters.

The package includes precompiled libraries for Microsoft C, QuickC, and Borland Turbo C. For Microsoft C, it includes libraries for generating bound applications that run under both DOS and OS/2.
Price: $149.
Contact: Blaise Computing, 2560 Ninth St., Suite 316, Berkeley, CA 94710, (415) 540-5441.
Inquiry 1104.

Zap Your Apps into PROMS

If you need to turn an IBM PC into a diskless standalone workstation or protect your custom code from prying eyes and piracy, Annabook's PromKit can help by putting any DOS program (or even DOS itself) into EPROM or static RAM (SRAM).

With a one-line command, you can turn an application or DOS into a binary image that you can load into a PROM and place into a PC motherboard or add-in card. PromKit lets you choose which drives you want to emulate. And if you use SRAM, the PC can even write to the drive.

The company says that even though the PC's EPROM address space is limited, you can use paged EPROMs to emulate a full 360K-byte drive by using three 27011 chips for data and a single 27128 for the driver module.

PromKit comes with complete source code (written in Microsoft C 5.1), including listings for utilities that convert files from binary to Intel hex format, and split files into even and odd bytes. To use PromKit, you'll need an IBM PC or compatible, 640K bytes of RAM, a hard disk drive, and an EPROM programmer.
Price: $179.
Contact: Annabooks, 12145 Alta Carmel Court, Suite 250–262, San Diego, CA 92128, (619) 271-9526.
Inquiry 1105.

continued

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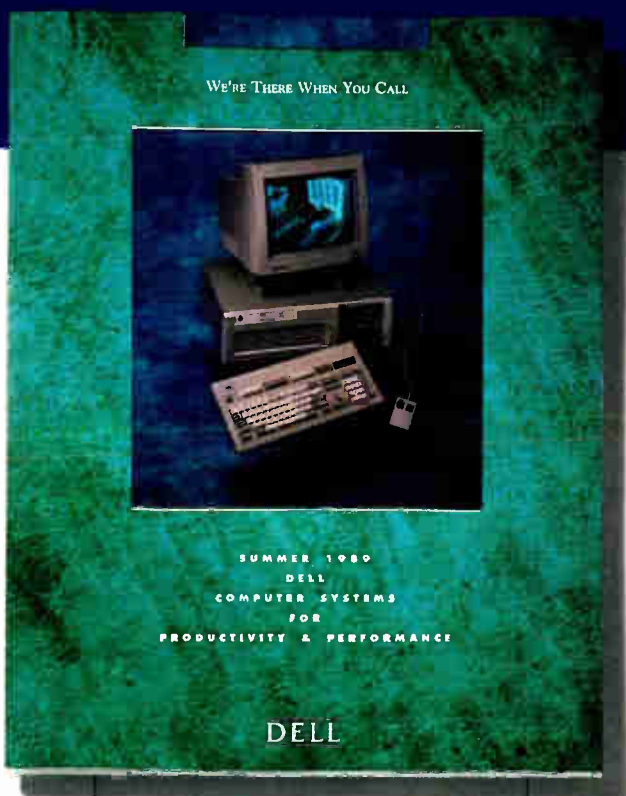

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11EK9

What better way to run Novell's 386 NetWare.

Novell's new 386 NetWare® will do for networking what gunpowder did for negotiating leverage. Provided you've got a 386 machine that's designed to be 100 percent compatible with it.

Not to worry.

Samsung's LAN hardware was co-designed by Novell® Which should put any compatibility concerns to rest. That's why the Samsung/Novell co-label is on our 386AE Fileserver and our PCterminal/286 LAN workstation.

NETWORKING vs. NOTWORKING.

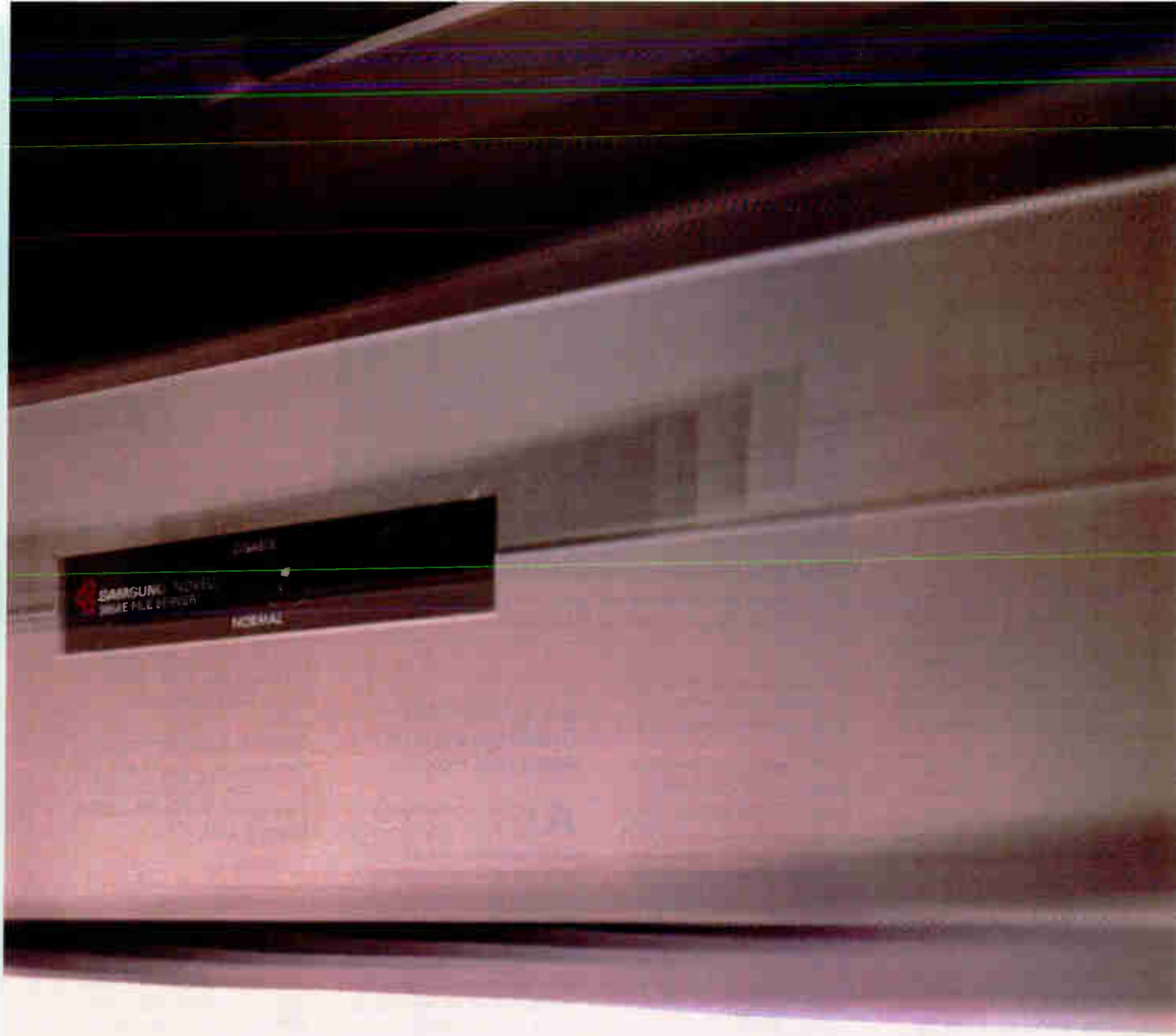
Both the Samsung 386AE and PCterminal/286 have been tested exhaustively by Novell for compatibility with popular networking hardware and NetWare products. In fact, no other LAN hardware has ever undergone such extensive testing.

But then Samsung and Novell didn't set out to desigr just another make-do desktop computer.

Samsung's 386AE Fileserver, for example, wa designed from the bus up to be a high-performance fileserver, starting with its Novell-developed BIOS. It also sports eight expansion slots for the inevitable inventory of interface and controller cards. Plus an oversize power supply capable of driving the requisite 100 megabyte-plus hard disk, tape backup system, etc. And it includes 4 megabytes of high-speec RAM for disk caching.

A TOTAL LAN SOLUTION.

To maintain NetWare compatibility throughout



your network, choose Samsung's PCterminal/286, a Novell-tested LAN workstation. Inside you'll find a built-in Ethernet interface adapter, and functional features like Novell's NetWare Autoboot EPROM.

THE NO BOTTLENECK ETHERNET CARD.

Our new SE2100 Ethernet interface eliminates the network bottleneck. Designed by Samsung, this high-performance 16-bit card provides twice the throughput of other Ethernet interfaces. And you can retrofit your existing workstations and fileservers with the SE2100 for dramatic improvements in your network's productivity.

LOOK FOR THE CO-LABEL.

The partnership between Samsung and Novell has created a hardware/software compatibility standard unparalleled in the industry. That means your network can experience all the speed of Novell's new 386 NetWare without being subjected to a lot of hardware hiccups.

Just look for the Samsung/Novell co-label. You'll find it at your nearest reseller. For the location, call **1-800-366-7472.**

SAMSUNG

Circle 301 on Reader Service Card (DEALERS: 302)

SOFTWARE • CAD AND GRAPHICS

Generic Moves in Three Dimensions

A fairly intuitive drawing process and two navigational aids to help three-dimensional drawing are what make Generic 3D Drafting an easy-to-use 3-D CAD program, reports Generic Software.

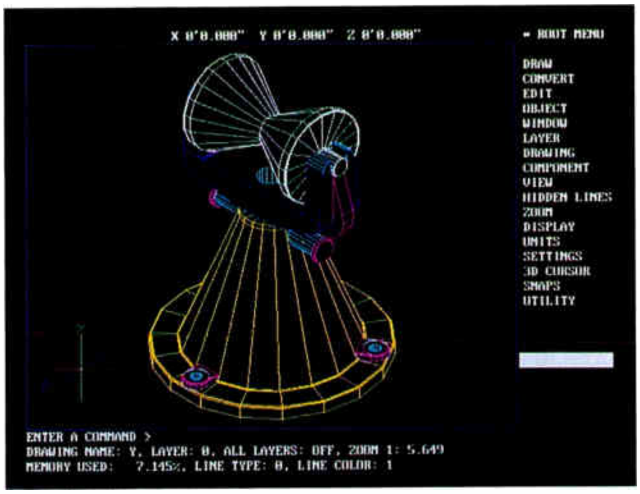
The program's interface is the same as in Generic's 2D CADD program, making it easy for 2-D users to move up to 3-D, according to Generic. You can also draw 2-D objects and then extrude and further manipulate them to create a 3-D object.

One of the navigational aids is a color-coded cursor, which you can label with *x*, *y*, and *z* directions. The other aid is called *tracking*, which allows you to move along any axis to any given point in space by moving the cursor instead of typing in coordinates.

3D Drafting is compatible with Generic CADD drawing files. It also gives you 256 layers, 256 colors, and 256 line types. An in-depth tutorial not only instructs you on how to use the program but also gives you basic lessons in 3-D drafting.

The program requires an IBM PC with at least 640K bytes of RAM and a graphics display with a resolution of at least 640 by 200 pixels. The company recommends EMS memory and a math coprocessor.

Price: $249.95.
Contact: Generic Software, Inc., 11911 North Creek Parkway S, Bothell, WA 98011, (800) 228-3601 or (206) 487-2233.
Inquiry 1123.



You can draw three-dimensional objects such as this gravity saw support using Generic's familiar 2D interface.

Bring Non-CAD Drawings into the AutoCAD Fold

A program called LunaSeries lets you scan non-CAD drawings into a CAD program and view, archive, edit, and store the image on your CAD system or network. Once a raster image is loaded into the CAD system, you can make on-screen changes. The program displays the original image and your changes. After editing the image, you can merge the original drawing with your changes and save them in CAD format.

Version 2.31 of the program now supports all high-resolution graphics cards. At press time, American Imaging Systems was developing a version that supports all Hewlett-Packard Graphics Language plotters.

LunaSeries runs on the IBM AT or higher with 640K bytes of RAM, 512K bytes of expanded memory, AutoCAD 2.6 or higher, VersaCAD 5.3 or higher, or CADKEY 3.5 or higher. Later this year, according to the company, the program will support IBM CAD and Sun workstations.

Price: $2185 per workstation.
Contact: American Imaging Systems, Inc., 2315 Luna Rd., Carrollton, TX 75006, (800) 234-7226 or (214) 484-3339.
Inquiry 1121.

AutoCAD Site-Planning Modules for the Mac

A set of applications from LandCADD lets you capture AutoCAD designs and customize them for land planning. The Site Planning and Landscape Design module includes a symbols library and routines for parking, coordinate geometry, topography, and cut and fill.

LandCADD runs on the Mac II or IIx with AutoCAD, 4 megabytes of memory, and 8 megabytes of free space on your hard disk drive.

Price: Site Planning and Landscape Design, $695; Irrigation Design, Quadrangle DTM, and EZ-Estimate Plus, $595 each; CADD Construction Details, $895; Plant Specifier, $295.
Contact: LandCADD, Inc., 7519 East Highway 86, Franktown, CO 80116, (303) 688-8160.
Inquiry 1120.

continued

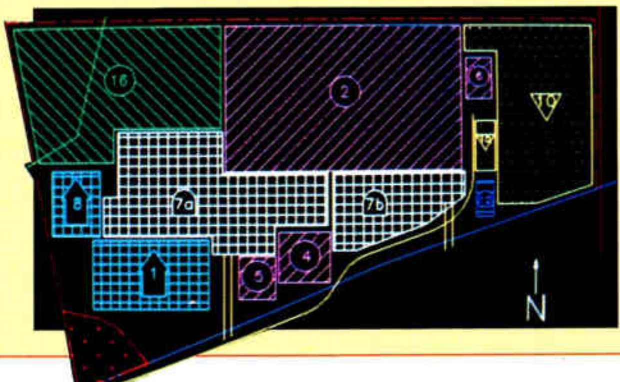
AutoCAD Add-on Helps Draw Industrial Facilities

FactoryCAD is an industrial facilities design and drafting program you can use within AutoCAD. The program's functions and routines automatically generate walls, doors, grids, docks, conveyor belts, and other functions that help you design facilities.

The program has more than 70 predefined layers; you can extract a layer from one drawing and insert it into another. FactoryCAD's utilities can draw power lines, water, compressed air, gas, and steam, each on its own layer with its own color.

The program works on the IBM AT or higher with 640K bytes of RAM, a math coprocessor, 1.5 megabytes of extended memory, and AutoCAD release 9 or 10.

Price: $695.
Contact: Cimtechnologies Corp., 525 East Second, Suite 500, Ames, IA 50010, (515) 232-9914.
Inquiry 1118.



QNX®

The OS for over-achievers™

QNX programmers have a decided advantage.

You see, people who use QNX enjoy the freedom that comes only with a flexible, modular OS. They appreciate the elegance of a **message-passing architecture**. And they marvel at the fact that QNX runs so lean—under 150K—yet out-performs any other PC operating system.

QNX users never worry about whether their applications will make it at runtime, because they know QNX has proven itself again and again in the real world.

It's no wonder that QNX users have achieved so much since the product was first released for the PC in 1982: over 80,000 systems installed in 47 countries world-wide, in all kinds of applications—from making cars to selling books to handling online credit card transactions.

One reviewer dubbed QNX "The multi-everything OS." Now, you might expect multiuser and multitasking, but realtime? *And* integrated networking? *And* true distributed processing? Best of all, these terms take on a new meaning with QNX.

Multiuser, for instance, means up to 32 terminals per micro. **Multitasking** cashes out as 150 tasks per machine. **Realtime** means not only priority-driven, preemptive task scheduling, but also speed: at 6,896 task switches/sec on a 16MHz 286, QNX is at least a full order of magnitude faster than a typical UNIX system. **Integrated networking** means you won't need yet another layer of software to set up a LAN, and you can use *any mix* of Intel-based micros—from vintage '81 PCs to PS/2s.

Distributed processing with QNX sounds too good to be true. But it is: *Any task can access any resource*—programs, files, devices, even CPUs—without going through the bottleneck of a central file server.

Besides the satisfaction that QNX developers get from using a fast, powerful, and flexible OS, did we mention that they also enjoy *free technical support?*

If you're wondering why you don't already know all about this great OS, you could try asking the over-achievers who are smugly guarding the secret of their success.

Better yet, give us a call. We'll tell you everything you need to know to become an over-achiever yourself.

QNX

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For more information or a free demo disk, please phone (613) 591-0931.

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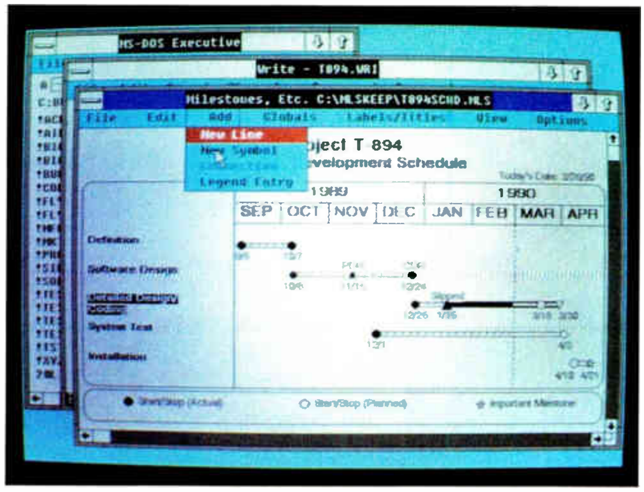
SOFTWARE • BUSINESS



Milestones, Etc. lets you place lines, symbols, and legend entries anywhere on your chart.

Create Gantt, Milestone Charts Under Windows

SoftPro developed Milestones, Etc. for businesses that need to create presentation-quality Gantt and Milestone charts. The program runs under Windows and features 28 symbol types, 15 connections, and the ability to lock a symbol onto a specified date.

With the program's current date-sensitive option, the program automatically blackens symbols prior to the current date and makes them hollow after the date. With this option, you can produce an updated chart that reflects the project's progress. Charts can be several pages long, and multiple-page charts can be numbered.

You can merge charts created with Milestones, Etc. with PageMaker, Ventura Publisher, WordPerfect, and any other program that accepts Windows metafiles or the Hewlett-Packard Graphics Language format.

Milestones, Etc. works on the IBM AT or higher with Windows 2.0 or higher and a Microsoft-compatible mouse.

Price: $89.
Contact: SoftPro, P.O. Box 1167, Manchaca, TX 78652, (800) 666-3886 or (512) 282-1544.
Inquiry 1125.

Five Forecasting Programs

Sales and marketing managers can use TSM Associates' Forecaster program to generate sales forecasts for products, companies, and individual sales personnel. The program comes in two versions: the distributor's version for the multiline distributor and manufacturer's representative, and the manufacturer's version.

Each version generates a variety of reports and has databases for forecast records, products, and individual personnel; the distributor's version also has a principal's database and breaks down sales by sales representative, products, customer, and time to purchase.

The Forecaster runs on the IBM PC with 512K bytes of RAM and a hard disk drive.
Price: $495.
Contact: TSM Associates, 4 La Cerra Dr., Rancho Mirage, CA 92270, (619) 321-5730.
Inquiry 1128.

continued

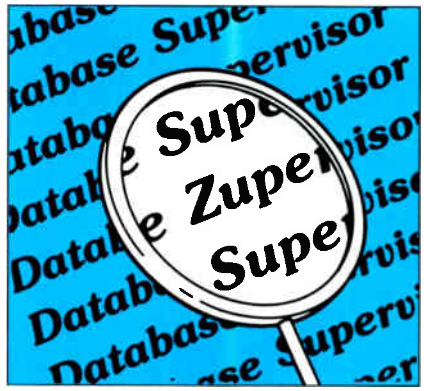
Intelligent Database Tools are Here!

Is your Database an Asset or just a File?

As your database grows, its potential value increases. Your challenge is to keep it error-free, understand it, and use it to make effective decisions. These are the tools you need:

DATABASE SUPERVISOR

Maintain data quality and data integrity. Keep your database error-free. Database/Supervisor analyzes your databases and identifies *suspicious data items*, and patterns which are out of the ordinary. It automatically detects errors which violate statistical or logical integrity constraints. *If your database is being corrupted, Database/Supervisor will show you where.*



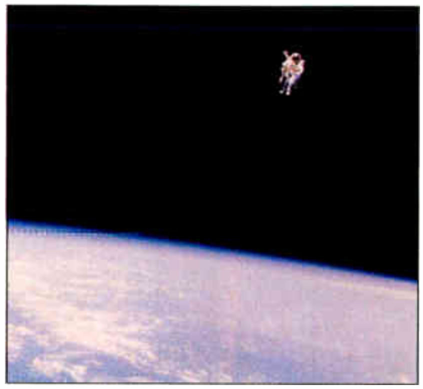
Will your database errors live forever?

IXL The Machine Learning SYSTEM

Discover *hidden patterns and unexpected relationships* in your large database. IXL analyzes your database and generates easy-to-read rules using artificial intelligence and statistical techniques. While Database/Supervisor detects errors, IXL produces rules and decision-making insight. *The solutions you are looking for may already be in your database, waiting to be discovered.*

NEURAL/QUERY

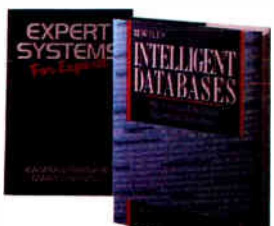
Don't deny yourself inexact, but potentially valuable, answers to your database queries. Close matches are more valuable than *no response*. IXL and Neural/Query are perfect partners. IXL generates rules which can be exported. However, Neural/Query analyzes your large database, builds a network of partial matches, and provides the closest matching answer to your database queries. *Use the full informational content of your database.*



Alone in a universe of data? Let IXL be your guide.

Intelligence Compiler

The highest-level, easiest-to-use intelligent database environment today. Build dialogs automatically, link them with rules, frames and hypertext *in minutes*. Develop your intelligent application quickly and efficiently, then run it on multiple operating systems. The built-in relational database combines expert system logic with SQL-based object oriented queries. *Accomplish in hours what would otherwise take weeks.*



Our leadership in this field of technology is unsurpassed. Ask for our books *Intelligent Databases* and *Expert Systems for Experts* by K. Parsaye, et al., published by John Wiley.

Experts love our software:

The Intelligence/Compiler is a powerful state of the art system for real-world applications. Its intelligent editing and debugging facilities are a bonus. *AI/Expert Magazine*, February 1988.

Considering the variety of features that the Intelligence/Compiler provides, it is hard to believe that you can get better value for your money. *PC/AI Magazine*, June 1989.

Having used IXL on a large database of geological test data, we were surprised by the many relationships it found. This has greatly helped us to interpret our Oil Company database. *Mr. James Brown*, Oil Industry Consultant, July 1989.

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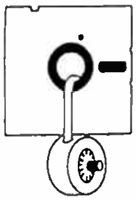
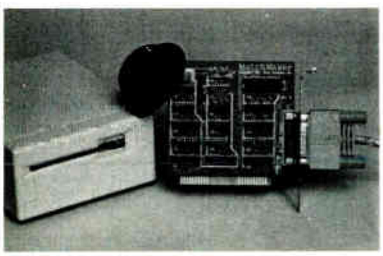
#3 in a series on consumer habits

The polar bear is the great white hunter of the Arctic Circle. Migrating long distances over the vast frozen desert, it tracks large prey such as seals and sea lions. In a sprint, it can reach speeds of up to 25 mph. When it raids the ice box, it doesn't waste energy on small fish. The readers of BYTE magazine are just as selective. For they, too, are relentless hunters with big appetites. They are advanced personal computing experts whose hunger for new product information is insatiable. They seek technical analyses. Extensive reviews. A complete rundown of product comparisons. Which is what they get in every BYTE. Some publications may promise you more paid readers than BYTE's 450,000. But none so voracious.





The NAI Forecasting System handles personnel forecasting for companies, including those that are in growth or downsizing cycles, acquiring other companies, or shifting personnel among divisions.

The program identifies human resource shortages and personnel for each of five future time periods, which you designate. The program's front end, a human resource data-gathering system, can import planning data from a Human Resource Information System database.

The NAI Forecasting System runs on the IBM AT or higher with a hard disk drive, DOS 3.0 or higher, 640K bytes of RAM, and a math coprocessor.
Price: $15,000.
Contact: Nardoni Associates, Inc., 157 Route 31, Lebanon, NJ 08833, (201) 730-9444.
Inquiry 1129.

With Tomorrow, you highlight a range of historical information on your Lotus 1-2-3 spreadsheet, including subtotals, summaries, and other formulas, and the program does the rest. Tomorrow doesn't require that you understand the complicated statistics of forecasting.

Tomorrow runs on the IBM PC with Lotus 1-2-3 release 2, 2.01, or 2.2 and requires 55K bytes of free RAM.
Price: $129.95.
Contact: Isogon Corp., 330 Seventh Ave., New York, NY 10001, (800) 662-6036 or (212) 967-2424.
Inquiry 1130.

ForeCalc is a statistical forecasting program that's designed as an add-on for Lotus 1-2-3 and Symphony.

As with Tomorrow, you specify from within your spreadsheet the history of the data, and ForeCalc automatically generates the forecasts. ForeCalc is designed for people with no prior knowledge of statistics.

ForeCalc incorporates several exponential smoothing models to create the forecasts and to choose the best technique automatically.

Unlike ForeCalc, Forecast Master Plus is for people familiar with statistics. Business Forecast Systems developed it for the professional business forecaster familiar with complicated forecasting models. You can choose from eight forecasting models, ranging from exponential smoothing and Box-Jenkins to variable parameter regression.

Forecast Master Plus works on the IBM PC with 640K bytes of RAM, a hard disk drive, and a math coprocessor.
Price: ForeCalc, $149; Forecast Master Plus, $695.
Contact: Business Forecast Systems, 68 Leonard St., Belmont, MA 02178, (617) 484-5050.
Inquiry 1131.

TopDown Steps up into Windows

TopDown, the project management program that lets you break down projects into a series of hierarchically arranged tasks, now supports Microsoft Windows, taking advantage of the Clipboard to export data to other Windows applications.

You can edit your PERT and Gantt charts in any window, and the program will flag critical and late activities.

TopDown Project Planner for Windows runs on an IBM AT or higher with Windows 286 or Windows/386.
Price: $249.
Contact: Ajida Technologies, Inc., 613 Fourth St., Santa Rosa, CA 95404, (707) 545-7777.
Inquiry 1124.

continued

If Looks Could Kill...

The ViVa24 Modem knocks 'em dead with style and convenience.

ViVa
MODEM 24

Finally! An affordable, state-of-the art modem designed to maximize any work station or desktop and take up minimal space. The new 2400 baud modem from Computer Peripherals, Inc. is a 100% Hayes compatable external modem which boasts more high-tech features than its competition at an unbelievable price tag.

The compact, distinctively sleek tower design simplifies placement, and it's easily accessible, front panel power switch eliminates fumbling around the back of the unit. The handsome weighted base holds the ViVa24 firmly in place, and sharp LED indicator lights are aligned for comfortable viewing, utilizing international graphic icons that make the ViVa24 simple to understand.

The small tower design creates a natural flow of air over the surface of the board, allowing the ViVa24 to run cooler and affording you 24-hour, worry-free operation. The Viva24 modem provides the user compatability with IBM PC, XT, AT, IBM PS/2, Apple Macintosh computers and any computer that supports RS-232C.

The ViVa24 modem represents innovation from its footprint up with features such as: use of the Hayes "AT" command set, asynchronous data format, auto-dialing, auto answer, adaptive equalization, non-volatile memory, automatic tone and pulse dialing, remote access while your computer is unattended, self-test and built-in diagnostics. Best, of all, the ViVa24 is fully backed with a five-year limited warranty.

Before investing in an ordinary modem, be sure to investigate the ViVa24. For more details, call your Ingram MicroD representative now at:

1-800-456-8000 (East)
1-800-642-7631 (West)

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CCI AT 286/12 MHZ

80286 Processor Running at 6 to 12 MHZ

Phoenix Bios/Digital Speed Display

80287 Math Co-Processor Socket

8 Expansion Slots 6-16 Bit, 2-8 Bit

2 Meg of 0-Wait State Memory (Expandable to 4)

1.2 Meg Floppy
1.44 Meg Floppy

40 Meg Seagate ST 251-1 (28 MSEC.)
WD Controller (1-1 Interleave)

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14" Multisynch Monitor 800 × 600 Tilt Swivel

Orchid Prodesign and 512K VGA Card

1-Parallel, 2-Serial, Game Port

101 Key at Keyboard with Dust Cover

DOS 4.01 with GW Basic or DOS 3.3 with GW Basic

Surge Supressor

1 Year Parts and Labor Warranty (FREE)

1 Year On-Site Service

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(No Restocking Fee)

2nd Year Warranty ($49.95)

Complete System Price $2195.00

FREE

Free with the purchase of any CCI System . . . one year, on-site warranty through Data Access Systems Inc. Provides response time of 8 business hours and covers all parts, labor, travel and technical support. Extended warranty available.

CCI AT 286/20 MHZ

80286 Processor Running at 20, Switchable to 10

Phoenix Bios/Digital Speed Display

80287 Math Co-Processor Socket

8 Expansion Slots, 6-16 Bit, 2-8 Bit

2 Meg RAM 0-Wait State (Expandable to 8)

80 Meg Seagate ST 4096 (28 MSEC.)
WD Controller (1-1 Interleave)

Norton SI 22.5

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CCI 386/25 MHZ CACHE

80386-25 MHZ Intel Processor 0-Wait State (32K Cache Memory)

AMI 386 Bios with an in ROM Set-up Routine

Socket Support for 80287, 80387 and Weitek Co-Processors

One 32 Bit Slot, Five 16 Bit Slots, and Two 8 Bit Slots

4 Meg Memory on Board, Expandable to 8MB, 1MB/2MB when using 256K D-RAM, 4MB/8MB when using 1M Bit D-RAM, Expandable to 16MB

1.2 Meg Floppy
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80 Meg Seagate-4096 (28 MSEC.)
WD Controller (1-1 Interleave)

Norton SI 30.5

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Mitsubishi Diamond Scan 14" 800 × 600 Tilt Swivel

Orchid Prodesign and 512K VGA Card

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KXP-1191	$ 399.95	$ 230.00
KXP-1592	$ 649.95	$ 389.00
KXP-1595	$ 729.95	$ 429.00
KXP-1124	$ 529.95	$ 315.00
KXP-1524	$ 899.95	$ 539.00
UF-150 FAX	$1,795.00	$ 955.00
UF-260 FAX	$2,795.00	$1,479.00

"FREE" Printer Cable

NEC LAPTOPS

		RETAIL	CCI PRICE
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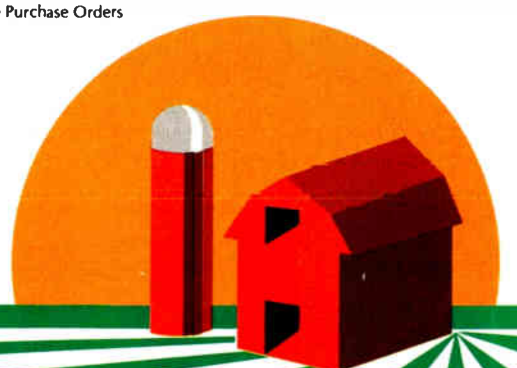

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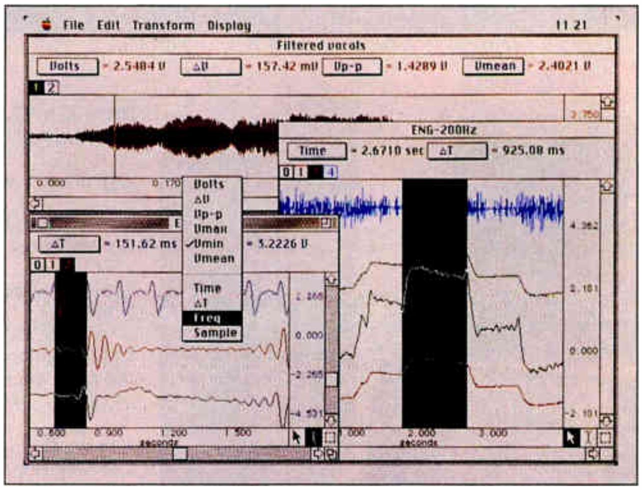
SCIENCE AND ENGINEERING



Transform your Mac into a digital signal processing workstation with AcqKnowledge.

Generate Waveforms Two Ways

Snap-Generator is a menu-driven program that generates waveforms using a D/A converter. You can generate standard functions, such as sine, cosine, square, triangular, and ramp, or you can define your own. For sources of output, you can use previously acquired data or HEM's Snap-Calc.

To run Snap-Generator, you specify the shape of the waveform and select AC or DC amplitudes within the range of the D/A. The waveform can be bipolar or unipolar. Swept-frequency waves let you quickly assess frequency response characteristics of the device under test, according to HEM. Sweep rates can be linear or logarithmic. The maximum D/A rate is 30,000 kHz. Up to 32,768 points are generated for a channel before the waveform is repeated. Snap-Generator can output eight channels, with each independently defined. It will also drive an *x,y* recorder.

Hardware requirements include an IBM PC running HEM's Snapshot Storage Scope and Snap-Calc, and an analog I/O board from Burr-Brown, Intelligent Instrumentation, or Heath/Zenith.

Price: Snap-Generator, $395; $1185 for all three software programs.

Contact: HEM Data Corp., 17336 Twelve Mile Rd., Suite 200, Southfield, MI 48076, (313) 559-5607.

Inquiry 1115.

AcqKnowledge lets you and your Mac work with waveform data. Included in the package are measurement, transformation, filtering, and spectral analysis functions, and both printing and file handling capabilities. For presentations, you can cut and paste AcqKnowledge graphics into any word processing or desktop publishing package.

Among AcqKnowledge's waveform processing capabilities are digital filtering (low-pass, bandpass, high-pass, and notch); spectral analysis using fast Fourier transfers; waveform integration, differentiation, and smoothing; scalar and delta amplitude and time measurements; and waveform arithmetic.

Biopac says that AcqKnowledge is directly compatible with all of the company's data acquisition hardware, but it also works with any data acquisition system that can store data in a text format. If you want to customize the

continued

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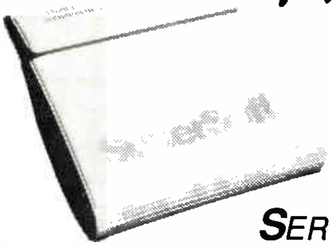

SCIENCE AND ENGINEERING

package, it comes with both textual and mathematical descriptions of the signal-processing algorithms that it uses. AcqKnowledge works with all models of the Macintosh from the 512KE up.
Price: $495.
Contact: Biopac Systems, 5960 Mandarin Dr., Suite D5, Goleta, CA 93117, (805) 967-6615.
Inquiry 1116.

Interactive Neural Network Simulation

Desire/Neunet is an integrated environment that simulates neural networks. It includes a screen editor, compiler, and debugger and lets you combine up to 16,380 neurons and 16,380 interconnections.

The run-time compiler generates processor-specific 80287 or 80387 machine code for matrix computations and differential equations. You can simulate network paradigms, such as back propagation, counterpropagation, bidirectional associative memories, competitive learning, and adaptive resonance. The program also offers six integration rules and handles multirun experiments, complex frequency-response plots, fast Fourier transforms, and matrices.

Desire/Neunet runs on the IBM AT with 500K bytes of RAM, an 80287 or 80387 math coprocessor, and an EGA or VGA card.
Price: $695.
Contact: Korn Industrial Consultants, 6801 Opatas St., Tucson, AZ 85715, (602) 298-7054.
Inquiry 1112.

Math and a Whole Lot More

Formula/One, a math program that features presentation graphics, now supports dBASE II, III, and III Plus databases, and Lotus 1-2-3 and Excel spreadsheets. It is also compatible with CGA, EGA, VGA, MCGA, and Hercules graphics cards.

According to Ocean Isle Software, Formula/One 2.0 solves up to 250 simultaneous equations and processes arrays of up to 8000 entries. It fits linear and nonlinear curves to your data and performs advanced multivariable linear-regression analysis for up to 10 independent variables.

You can input your equations with values for all known variables, and the program will solve for all unknown variables no matter where they appear in the equation. It also has 73 built-in functions, including common trigonometry, logarithms, and general math functions, and a set of business math functions.

You can also create an application display in which you can create a fill-in-the-blanks-type screen for an inexperienced user to fill in with any known values. The program will then fill in the rest.

The program also supports a mouse and features pull-down menus.

Formula/One 2.0 runs on the IBM PC, XT, AT, and PS/2s with DOS 2.1 or higher and 385K bytes of RAM. It also supports math coprocessors.
Price: $295.
Contact: Ocean Isle Software, Ocean Isle Square, Building 3, Ocean Isle Beach, NC 28459, (800) 882-8664.
Inquiry 1113.

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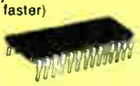
INTEL MATH COPROCCESORS



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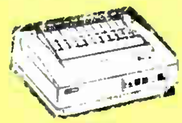

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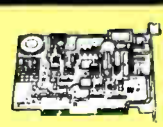

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Optical Storage Field Study on the Eastern Seaboard

Rothchild Consultants is sponsoring a study mission that will give participants an opportunity to visit organizations that use optical disk systems and applications. The tour, which will include demonstrations and interactive discussions, begins in New York on October 20 and ends in Washington, D.C., on October 27.

The field study will follow a tutorial workshop and conference on optical storage for large systems, which is being held in New York City's Grand Hyatt Hotel on October 17–19.

Price: Study mission only, $5495; conference only, $995; conference, tutorial, and mission, $6125.

Contact: Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116, (415) 681-3700.

Technology Conference and Seminar Nanobytes

The Baltimore Computer Conference and Exposition, organized by the Maryland Association of Certified Public Accountants and National Trade Productions, is expected to become an annual event. It will be held at the Baltimore Convention Center on December 13–14. One of the five session tracks will focus on digital image/optical disk technologies and applications.

Price: Conference: one day, $35; both days, $50; exposition is free.

Contact: National Trade Productions, Inc., 313 South Patrick St., Alexandria, VA 22314, (800) 638-8510 or (703) 683-8500; Maryland Association of CPAs, 1300 York Rd., Suite 10, P.O. Box 484, Lutherville, MD 21093, (301) 296-6250.

The Northeast Computer Conference and Expo, formerly the Northeast Computer Faire, will take place at the Bayside Exposition Center in Boston on October 12–14.

Price: Three days, $15; one day, $9.

Contact: The Interface Group, Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600.

Clearpoint Research will hold a two-day symposium called Policy and Parity: U.S.-Japan High Technology Trade Policy. The symposium will take place on October 12–14 at the World Trade Center in Boston. Clearpoint says the symposium will be an open forum for both countries to discuss trade policy issues.

Price: $400; students, $150.

Contact: Clearpoint Research Corp., 99 South St., Hopkinton, MA 01748, (508) 435-2000.

Messaging '89, the conference for integrated messaging applications, systems, and services, will be

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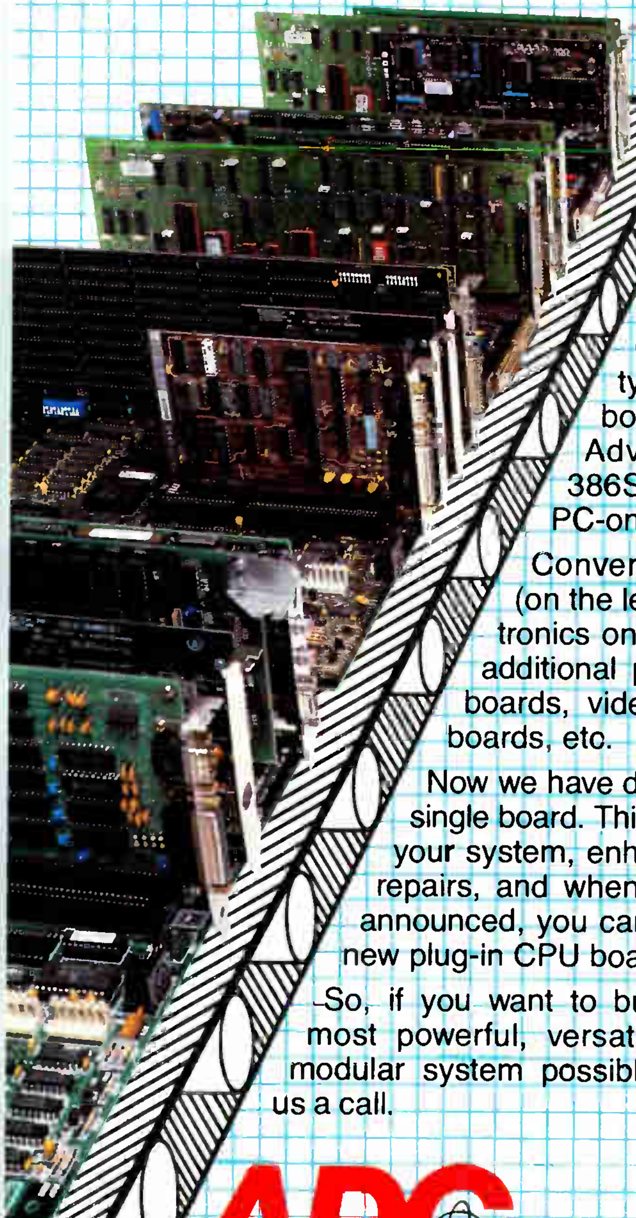

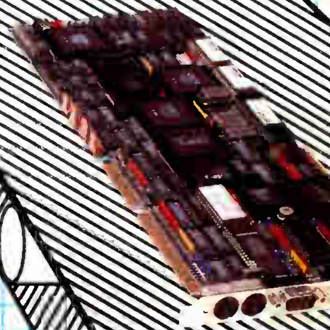

On the left are your typical PC/AT motherboards. On the right is Advanced Digital's SBC-386SX, a versatile, modular PC-on-a-board.

Conventional computer systems, (on the left), placed some of their electronics on the motherboard and required additional plug-in cards such as; memory boards, video graphic boards, serial/parallel boards, etc.

Now we have designed all of those functions onto a single board. This design provides the ability to upgrade your system, enhances serviceability by reducing costly repairs, and when the next generation of CPU chips are announced, you can offer your customers an upgrade with a new plug-in CPU board.

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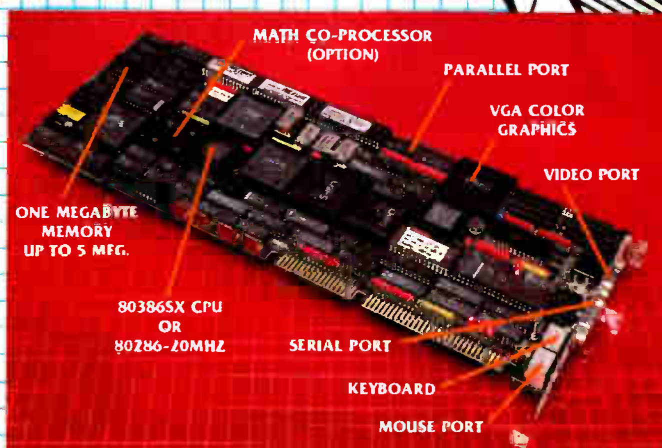

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Circle 521 on Reader Service Card (DEALERS: 522)

held on November 6–8 at the New York Hilton and Towers in New York City.
Price: Full conference, $795; exhibits only, no charge.
Contact: Messaging '89, Information Publishing Corp., P.O. Box 42375, Houston, TX 77242, (800) 777-4442 or (713) 974-6637.

Info '89, the conference for MIS and DP professionals, will be held at the Jacob K. Javits Convention Center in New York City on October 10–13.
Price: $20.
Contact: Cahners Exposition Group, 999 Summer St., Stamford, CT 06902, (203) 964-0000.

Binghamton, New York, will be the site of the 1989 IEEE Frontiers in Education conference, to be held on October 14–17. This year's theme is "New Directions in Engineering Education."
Price: $140.
Contact: Dr. Richard S. Culver, General Chairman, Watson School, State University of New York, Binghamton, NY 13901, (607) 777-2872.

The 1989 Workshop on Applications of Signal Processing to Audio and Acoustics will be held in New Paltz, New York. According to its organizers, topics will include signal processing relating to music, VLSI, wide-band audio, and speech signal processing. The conference, which will be held on October 15–18, was timed to coincide with the fall foliage.
Price: $75.
Contact: Stephen G. Rayment, Bell Northern Research, Box 3511, Station C, Ottawa, Ontario, Canada K1Y 4H7, (613) 763-4537.

The magazine that covers the Tandy Color Computer, *Rainbow*, is sponsoring Rainbowfest at the Hilton in Somerset, New Jersey, on October 20–22. Tutorials and exhibitions are for the Color Computer only.
Price: Three days, $9; one day, $7.
Contact: *Rainbow*, The Falsoft Building, 9509 U.S. Hwy. 42, P.O. Box 385, Prospect, KY 40059, (502) 228-4492.

The Philadelphia Civic Center will be the site for the fifth annual Scientific Computing and Automation Conference and Exposition on October 11–13. The show is dedicated to computing and automated technology.
Price: Three days, $95.
Contact: SCACE '89, Don Weise, 301 Gibraltar Dr., P.O. Box 650, Morris Plains, NJ 07950, (201) 292-5100.

A conference on computer security for the government and the private sector will be held at the Baltimore Convention Center on October 10–13. The Twelfth Computer Security Conference will focus on systems application guidance, security education and training, and more.
Price: $175.
Contact: Irene Gilbert, A254 Technology Building, National Institute of Standards and Technology, Gaithersburg, MD 20899, (301) 975-3360.

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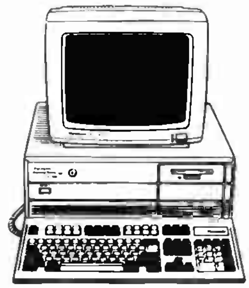

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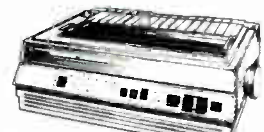

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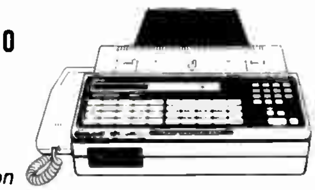

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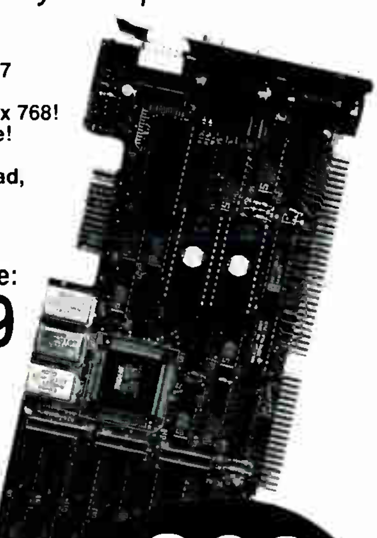

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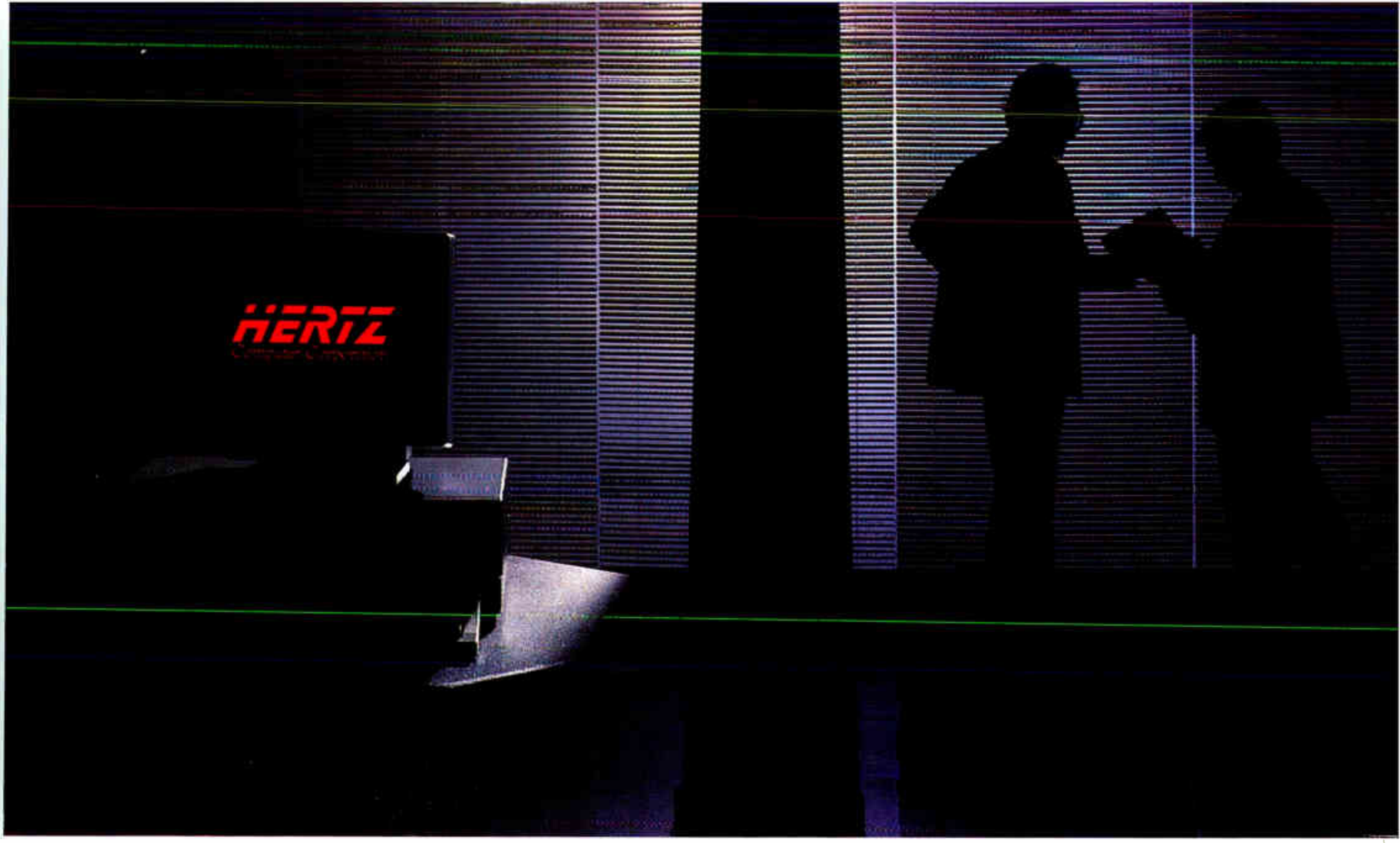

PC MAGAZINE September 13, 1988
"Ahead of the Pack: The Hottest 386s"

"Built solidly, performs well... don't pass it over when you shop for your next power PC..."

May 30, 1989
"PC Labs tested 104 computers from 58 companies"

"Hertz Computer... reliability and quality are its sales tools... the machines exemplify the company's commitment to engineering dependable systems... they are the ones to look at if your priorities are dependability and reliability..."

INFO WORLD November 14, 1988
"InfoWorld looks at the eight fastest 386 machines"

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May 1, 1989
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- Intel 80386-25 C.P.U.
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- 8 Industry Standard Expansion Slots
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- 2 Cooling Fans
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HERTZ 386/25			MONOGRAPHIC BOARD & MONO MONITOR			VGA 16-bit BOARD & 14" VGA MONITOR		
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40MB	MFM	28ms	$ 4699	$ 4969	$ 5399	$ 5299	$ 5569	$ 5999
72MB	MFM	28ms	$ 4879	$ 5149	$ 5579	$ 5479	$ 5749	$ 6179
160MB	ESDI	16ms	$ 5599	$ 5869	$ 6299	$ 6199	$ 6469	$ 6899
330MB	ESDI	17ms	$ 6169	$ 6439	$ 6869	$ 6769	$ 7039	$ 7469
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101-key Keyboard, 200W power supply;
Serial, Parallel & Game ports;
Monitor & controller card are optional.
Cache memory size = 64K (386 cache system only.)

CONFIGURATION	16MHz	20MHz	25MHz	33MHz
80386 Cache System (M:1MB, F:1.2M, H:40M)	N/A	$2645	$3145	$3490
80386 Basic System (M:1MB, F:1.2M, H:40M)	$2095	$2295	$2670	$2950
80386SX Basic System (M:1MB, F:1.2M, H:20M)	$1565	N/A	N/A	N/A

CONFIGURATION	8MHz	10MHz	12MHz	16MHz	20MHz
80286 NEAT System (M:1MB, F:1.2M, H:20M)	N/A	N/A	$1345	$1545	$1695
80286 Basic System (M:1MB, F:1.2M, H:20M)	$945	$1095	$1195	$1395	N/A
80286 Basic System (M:640KB, F:1.2M, H:20M)	$895	$1045	$1145	N/A	N/A

CONFIGURATION	4.77MHz	8MHz	10MHz
8088 Basic System (M:640KB, F:360K, H:20M)	$695	$725	$765
8088 Starter System (M:256KB, F:360K, H:None)	$345	$365	$385

Monitor Options

CONFIGURATION	12" Monitor	14" + Monitor
Mono Monitor w/MGP Card (Amber/White/Green)	$129	$150
Color Monitor w/CGP Card (RGB,640×240)	N/A	$275
EGA Color Monitor (640×350) w/EGA Card	N/A	$450
Multisync EGA Monitor (640×480/800×600) w/EGA Card	N/A	$635
VGA Monitor (640×800/800×600) w/VGA Card	N/A	$615

8088 Based Multi-User Terminal (with Mono Monitor, 84 Kybrd & Srl/Prl ports)

CONFIGURATION	4.77MHz	8MHz	10MHz
8088 Basic Terminal (M:256KB, F:360K, H:None)	$399	$429	$459
8088 Minimum Terminal (M:64KB, F:None, H:None)	$249	$269	$289

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Expansion slots;

CONFIGURATION	MEM	MM SPC	FDD	HDD	BATTRY	DSP CMPL	PRICE
80286 12MHz VGA Plasma Laptop	1M	5M	1.44M	40M	None	MG/CG/VG	$3795
80286 12MHz CCFT EGA LCD Laptop	1M	4M	1.44M	40M	1.5 hr	MG/CG/EG	$3195
80286 12MHz Plasma Laptop	640K	4.6M	1.44M	20M	None	MG/CG	$2495
8088 10MHz LCD Laptop	1M	1M	2×720K	None	8 hr	MG/CG	$1045

HK-4080/5080 Portable Computer

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CONFIGURATION	9" EGA	9" AMBR	PLASMA	HR-LCD	EG-LCD	VG-PLSM
80386 16MHz Prtbl (F:1.2M, M:1MB)	$3275	$2350	$3125	$2685	$3025	$3785
386SX 16MHz Prtbl (F:1.2M, M:1MB)	$2975	$2050	$2825	$2385	$2725	$3485
80286 12MHz Prtbl (F:1.2M, M:1MB)	$2595	$1675	$2495	$1920	$2395	$3090
8088 10MHZ Prtbl (F:360K, M:640KB)	$2165	$1275	$2165	$1495	$2065	$2795
Note: Gross Weight (lb)	42	38	26	23	23	26
Expansion slot	3	3	2	2	2	2

System Board Speed: 8, 10, 12, 16, 20, 25, 33MHz available, please call.

HK-7000 Industrial Control Terminal

(with System Board, Serial Port, Opt. I/O, 12-bit AD/DA brds)

CONFIGURATION	DIG-IN	DIG-OUT	A-TO-D	D-TO-A	OPTION	PRICE
8088 Remote Control Termml	32	8	8	3	None	$1295
80286 Remote Control Termml	32	8	8	3	None	$1695

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HK-774P Eight-port intelligent SrL Adap for PCMOS	$545
HK-774U Eight-port intelligent SrL Adap (UNIX/XENIX)	$695
HK-775 Enhanced Ethernet Controller Card (8-bit)	$229
HK-776 Enhanced Ethernet Controller Card (16-bit)	$324
HK-778 3278/3279 Emulation Card	$279

Monitors

HK-338 Magicsync Hi-Res VGA Monitor (820×600)	$445
HK-321 Relisys VGA Monitor (720×480)	$395
HK-337 Magicsync Multisync EGA Monitor (820×600)	$485
HK-322 Relisys Multisync EGA Monitor (800×560)	$485
HK-324 NEC MultisyncIIA EGA Monitor, 800×560 (Analog)	$590
HK-328 Voltron EGA Monitor, 640×350 (TTL)	$349
HK-312 Casper RGB Monitor, 640×350 (TTL)	$239
HK-336 Magicsync Portrait Mono Monitor (768×1024)	$345
HK-314 BTC/Voltron 14" Mono Monitor (720×350)	$98
HK-311 Caspar/Voltron 12" Amber Monitor (720×350)	$76
HK-320 Center 12" Green Monitor (720×350)	$62

Display Controller Adaptors

HK-120A VGA Controller Card (800×600, 16-bit)	$219
HK-120 VGA Controller Card (800×600, 8-bit)	$185
HK-119 Super EGA Controller Card (800×600)	$138
HK-118 Autoswitch EGA Controller Card (640×480)	$109
HK-116 Color Graph & Mono Graph Card w/PP	$59
HK-115 Color Graph Controller Card (640×200)	$42
HK-114 Color Graph Controller Card w/PP (640×200)	$46
HK-113 Full Page HR Mono Graphic Card (768×1024)	$325
HK-112 Monochrome Graphic Card w/PP (720×348)	$48

Printers

Panasonic 1191 Dot Mtrx Printr (9-pin, 110cps, 80clm)	$234
Panasonic 1124 Dot Mtrx Printr (24-pin, 120cps, 80clm)	$355
Panasonic 1524 Dot Mtrx Printr (24-pin, 120cps, 132clm)	$515
Panasonic 1592 Dot Mtrx Printr (9-pin, 180cps, 132clm)	$415
Panasonic KX-P4450 Laser Printer	$1405
HP Laserjet Series-II Laser Printer	$1695

Floppy Disk Drives

BRAND	1.44MB	1.2MB	720KB	360KB
Fujitsu	$93	$83	$85	$69
Teac	$97	$87	$87	$77
Toshiba	$92	$85	$83	$73
Chinon	$89	$79	$80	$68

Hard Disk Drives & Tape Backup

BRAND-MODEL	SIZE	CAPACITY	ACS-TIME	PRICE
Seagate-125	3.5"HH	20MB (MFM)	40/28	$239/$275
Seagate-138	3.5"HH	30MB (MFM)	40/28	$285/$319
Seagate-138R	3.5"HH	30MB (RLL)	40/28	$255/$289
Seagate-225	5.3"HH	20MB (MFM)	65	$219
Seagate-238R	5.3"HH	30MB (RLL)	65	$244
Seagate-251-1	5.3"HH	40MB (MFM)	28	$369
Seagate-277R	5.3"HH	65MB (RLL)	40/28	$429/$519
Seagate-4096	5.3"FH	80MB (MFM)	28	$579
Seagate-4144R	5.3"FH	121MB (RLL)	28	$889
Toshiba-MK134 FA	3.5"HH	42/64/81(M/R/C)	25	$439
Toshiba-MK72PC	5.3"HH	73MB (MFM)	28	$599
Toshiba-MK156 FA	5.3"FH	147MB(ESDI)	23	$1279
Mnscrb-3180E	5.3"FH	157MB(ESDI)	17	$1345
Mnscrb-9380E	5.3"FH	338MB(ESDI)	17	$1950
CMS-DJ10 Jumbo	5.3"HH	40/60MB Int	Tape Bkup	$295

FLP DSK & HRD DSK DRV Control Cards

MODEL	FUNCTION	BIT	PRICE
HK-121	360KB FDDC	8	$34
HK-122A	360K/720K/1.2M/1.44MB FDDC	8	$54
HK-127	MFM HDDC (WD-GEN/DTC-5150X)	8	$69
HK-128	RLL HDDC (WD-27X/DTC-5160X)	8	$79
HK-129	Comprsed HDDC (Perstor XT)	8	$210
HK-227	MFM 3:1 H/FDDC (WA5/MM2)	16	$86
HK-227A	MFM 3:1 H/FDDC (WA3-16MHz)	16	$99
HK-227F	MFM 1:1 H/FDDC (DTC-7280/MM5)	16	$142
HK-228	RLL 3:1 H/FDDC (DTC-5287)	16	$139
HK-228F	RLL 1:1 H/FDDC (DTC-7287)	16	$159
HK-229	Cmprs 1:1 H/FDDC (Perstor)	16	$319
HK-229E	ESDI 1:1 H/FDDC (WDC)	16	$209
HK-229S	SCSI 1:1 H/FDDC (Seagate)	16	$69

Accessories

MODEL	FUNCTION	PRICE
HK-484	External Drive Case w/Cable (1HH)	$75
HK-485	Extrnl Drv Case w/60W Pwr Supl (2HH)	$95
HK-631	300W Uninterruptable Power system	$245
HK-620	6 Outlets Power Pad (6 switches)	$23
HK-850	Parallel Printer Cable (6ft/10ft)	$8/$10
HK-680	Keyboard Storage Drawer (metal)	$32
HK-7811/E	1200 BAUD Internal/External Modem	$64/$74
HK-7821/E	2400 BAUD Internal/External Modem	$98/$108

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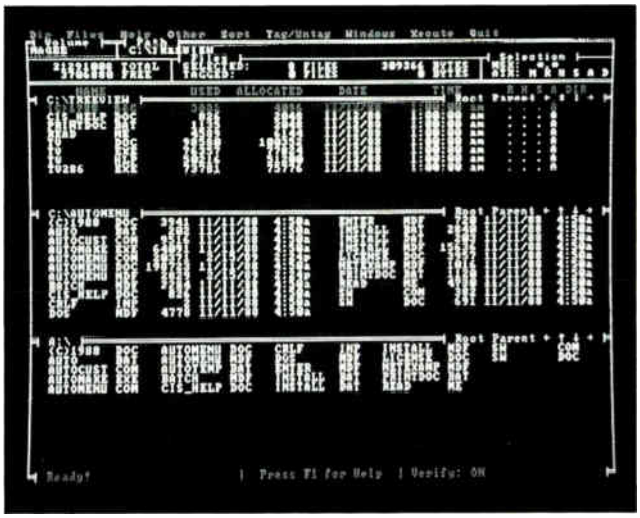
Circle 551 on Reader Service Card

DOS Tree Program for $50

Treeview is a hard disk file manager that displays your files in a tree-like structure. Advanced features of the program include the ability to display up to six directories or drives simultaneously, EGA 43-line/VGA 50-line mode support, and support for up to 30 definable function keys. The program works on the IBM PC with DOS 2.0 or higher and 256K bytes of RAM.
Price: $50.
Contact: Magee Enterprises, Inc., P.O. Box 1587, Norcross, GA 30091, (404) 446-6611.
Inquiry 1009.



A Treeview display, showing the contents of two directories and drive A in 43-line mode.

Fast 3-D Gets Silicon

Video control and drawing (VCAD) chips, Vermont Microsystems claims, permit Unix-based PCs with X/Series graphics boards to produce three-dimensional wire-frame and solids renderings at workstation speeds.

With the Texas Instruments TMS34010 graphics engine, the X/Series graphics boards can produce 3-D images at 1280- by 1024-pixel resolutions.

The base configuration board produces 400,000 2-D 10-pixel vectors per second, 70,000 characters per second, and 11 million pixels per second scrolling. It contains up to 1 megabyte of RAM and is available in 16 or 256 colors. It's also field-upgradable with modules, or you can buy boards with the modules included in either 2-D or 3-D configurations.

The Math module, which includes an AT&T DSP32C math coprocessor for 32-bit floating-point calculations, gives the Cobra Station a performance of up to 25 MFLOPS. It can produce 195,000 3-D vectors per second.

The Z-buffer module replaces the painter's algorithm with hardware for hidden surface removal. With the Cobra Station, it is capable of producing 10,000 hidden, Gouraud-shaded triangles per second.

Boards that bundle the base configuration board with these modules are called the X/Series Math, X/Series Z, and X/Series Math Z. The top-of-the-line X/Series Math Z is capable of producing 384,000 vectors per second and 22,000 hidden, Gouraud-shaded triangles.
Price: 16-color Cobra Station 2-D, $2995; 256-color Cobra Station 2-D, $3995; X/Series Math, $5795; X/Series Z, $7295, X/Series Math Z, $8295.
Contact: Vermont Microsystems, Inc., 11 Tigan St., P.O. Box 236, Winooski, VT 05404, (802) 655-2860.
Inquiry 1014.

Design Detention Ponds with the Mac

Hydro Mac is a hydrographics program for civil and municipal engineers who need to design detention ponds using the rational method. With the program, you can design ponds of up to a square mile to accommodate water runoff.

Because the rational method is not suitable for the design of ponds larger than 640 acres, Hydro Mac is also available in a version that accommodates the Soil Conservation Service method, for larger projects.

Both programs work on the Mac Plus or higher with 1 megabyte of RAM, and they are compatible with MacWrite, MultiFinder, and the Imagewriter printer.
Price: $395; SCS version, $800.
Contact: Applications Design Group, 60 East Hanover Ave., No. 6, P.O. Box 512, Morris Plains, NJ 07950, (201) 285-5160.
Inquiry 1025.

Mac Program Helps Pediatricians with Telephone Triage

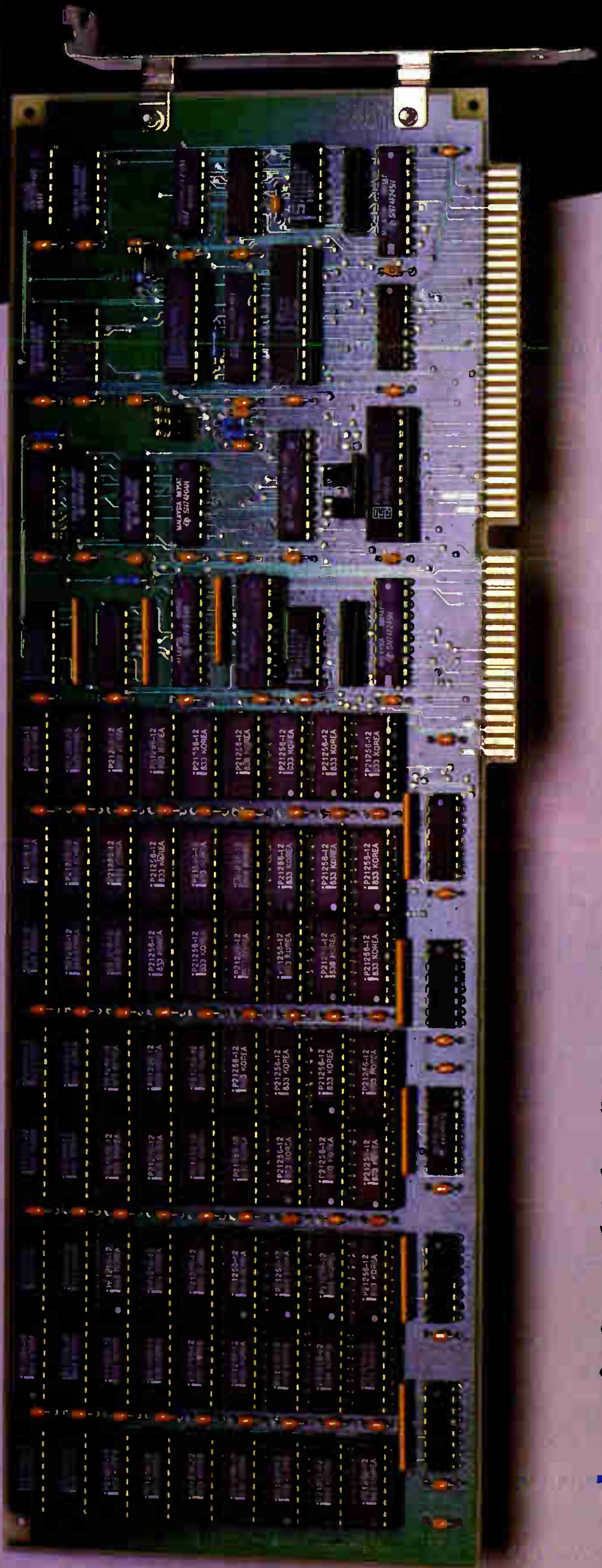
Triage, the process that doctors use to make decisions regarding the seriousness of an illness, is often performed by a pediatrician or staff member over the telephone. A program for the Macintosh called Pediatric Telephone Protocols (PTP) runs under HyperCard and lets a pediatric office do telephone triage efficiently while providing a way to document each incoming call and flag phone calls for follow-up.

When a parent calls in with a child's medical problem, the first screen lets you enter the patient's name, phone number, and other information. Then, if the parent suspects chicken pox or knows only the symptoms, you click on the Find card. An appropriate complaint card appears with a horizontal triage line. If the patient has any symptom above the line, it recommends immediate medical attention. If the symptoms are below the line, a list of recommended home treatments appears with symptoms that, should they occur, would require a callback.

You can flag each phone encounter for later follow-up, print it for inclusion in a chart record, or store it to disk. You can also use the program to calculate a recommended dosage strength by the child's weight.

PTP works on the Mac Plus or higher with HyperCard. The program was written by a pediatrician and is based on *Pediatric Telephone Advice* by Barton D. Schmitt.
Price: $199.
Contact: HealthTek Medical Software, Inc., 9950 West 80th Ave., Suite 24, Arvada, CO 80005, (303) 420-7438.
Inquiry 1020.

X-BANDIT



Break the 640K DOS barrier and utilize the Advanced Features of the LIM 4.0 standard while using only one motherboard slot!

"should be very useful for DOS users who are straining the limits of the 640K barrier"
—BYTEweek June 12, 1989

DESIGN PHILOSOPHY

• The Teletek X-Bandit was specifically designed to utilize the advanced features of the Lotus/Intel/Microsoft EMS 4.0 Specification. Further, the X-Bandit's Segmented Memory Mapping capability allows the user to extend DOS size beyond the 640K barrier. It is available in both 8 and 16 bit versions for use in the IBM XT, AT, and compatibles.

MEMORY

• Segmented Memory Mapping allows the user to fill out unused memory segments between 640K and 1024K. By "claiming" unused portions of memory in 16K increments, the user effectively increases TPA size. LAN or custom software modules, for example, can be loaded into these high memory areas thus relieving the lower 640K of TPA for other application programs.

• Split Memory Addressing allows the user to fill out conventional memory to 640K.

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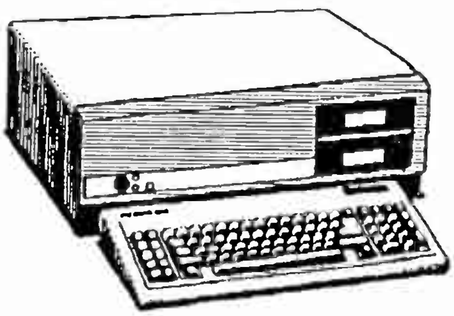

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MicroDirect's data management system features the Bondwell B300, an 80286-based 10-MHz laptop with 1 megabyte of RAM, a 10½-inch backlit LCD, a 20-megabyte hard disk drive, a 1.44-megabyte 3½-inch floppy disk drive, and a Hayes-compatible 300- or 1200-bps modem. Plug in the RJ-11 connector, and you're ready to travel. A carrying case encloses the 4- by 14- by 12-inch, 15-pound unit (including battery).

The Bondwell BFAX100 quadruples as a fax, a scanner, a copier, and a printer. It's a standard Group 3 (9600-bps) fax machine coupled with a 203-lpi by 98-lpi, 16-step halftone gray-scale scanner. Like most fax machines, it will also copy the 8½-inch-wide page on thermal paper, and its parallel port links it to the laptop for printing on the same thermal paper. The BFAX100 weighs 11 pounds. Dr. Halo III graphics software is included.

Price: $4500.
Contact: MicroDirect, Inc., 2010 Revere Beach Pkwy., P.O. Box 835, Everett, MA 02149, (800) 872-4286 or (617) 387-2200.
Inquiry 1011.

MicroDirect's laptop system includes a fax, a scanner, a copier, and a printer.

Animate to the Beat with PageSync

Mindware International's PageSync for the Amiga allows external MIDI events and computer animation to control each other. With the program, you can use a MIDI instrument to advance, stop, or reverse a computer animation. If you own a MIDI drum machine, you can use it to advance the animation by one frame per drumbeat, keeping the animation in time with the music.

PageSync can also do the opposite function, letting an animation running on an Amiga play the MIDI instrument.

PageSync runs on the Amiga 500, 1000, and 2500 with at least 1 megabyte of RAM.

Price: $100.
Contact: Mindware International, 110 Dunlop St. W, P.O. Box 22158, Barrie, Ontario, Canada L4M 5R3, (705) 737-5998.
Inquiry 1016.

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MacEnvelope Plus is a program that lets you manage your mailing lists and print postal bar codes on an envelope or label, entitling you to postage rate reductions in a bulk mailing.

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MacEnvelope Plus works on the Mac Plus or higher.

Price: $295.
Contact: Synex, 692 10th St., Brooklyn, NY 11215, (800) 447-9639 or (718) 499-6293.
Inquiry 1024.

80386 System Includes Its Own UPS

When you're introducing an 80386 system into an already-crowded market, one way to distance yourself from the pack is to include an uninterruptible power supply (UPS) and other devices normally considered optional: a 90-megabyte SCSI hard disk drive with a SCSI adapter, an 80-megabyte streaming tape drive, a 16-bit VGA controller, a 1024- by 768-pixel monochrome monitor, a mouse, and a surge protector with four outlets for external peripherals. The Echo386 base system includes MS-DOS 3.3, DESQview, and PC Tools.

By incorporating a battery into the system's power supply, Pan Overseas says that it was able to provide uninterruptibility at low cost. The system also comes with a small (4K-byte) TSR software package that will automatically back up the system onto a hard disk. If the power fails or if you turn the system off, the software saves an "image" of the system—including all running applications and TSR software—onto the hard disk. The next time you turn the system on, you have a choice of resetting the system or returning it to the same state it was in when the power was turned off.

Price: $4395.
Contact: Pan Overseas Computer, 44 Route 46, Pine Brook, NJ 07058, (201) 808-1900.
Inquiry 1012.

SkiSoft Word Processor Features Large Text

Eye Relief is a full-function word processor that lets you enlarge your text by as much as 300 percent.

The display text can range from the normal 80 columns by 25 rows up to 33 columns by 7 rows. Magnification is user-selectable in four modes. You can change the space between lines and the space between letters without creating jagged-edge letters. And you can make the cursor blink at any desired rate—or not at all, a feature important for epileptics because blinking lights often cause seizures.

The editor features flexible formatting for indentation and layouts, and it stores files in ASCII. You can define up to 46 macros, each tied to the Alt key. Eye Relief requires 512K bytes of RAM and MS-DOS, and it is compatible with Hercules, CGA, EGA, and VGA graphics.

Price: $295.
Contact: SkiSoft Publishing Corp., 1644 Massachusetts Ave., Suite 79, Lexington, MA 02173, (800) 456-8465 or (617) 863-1876.
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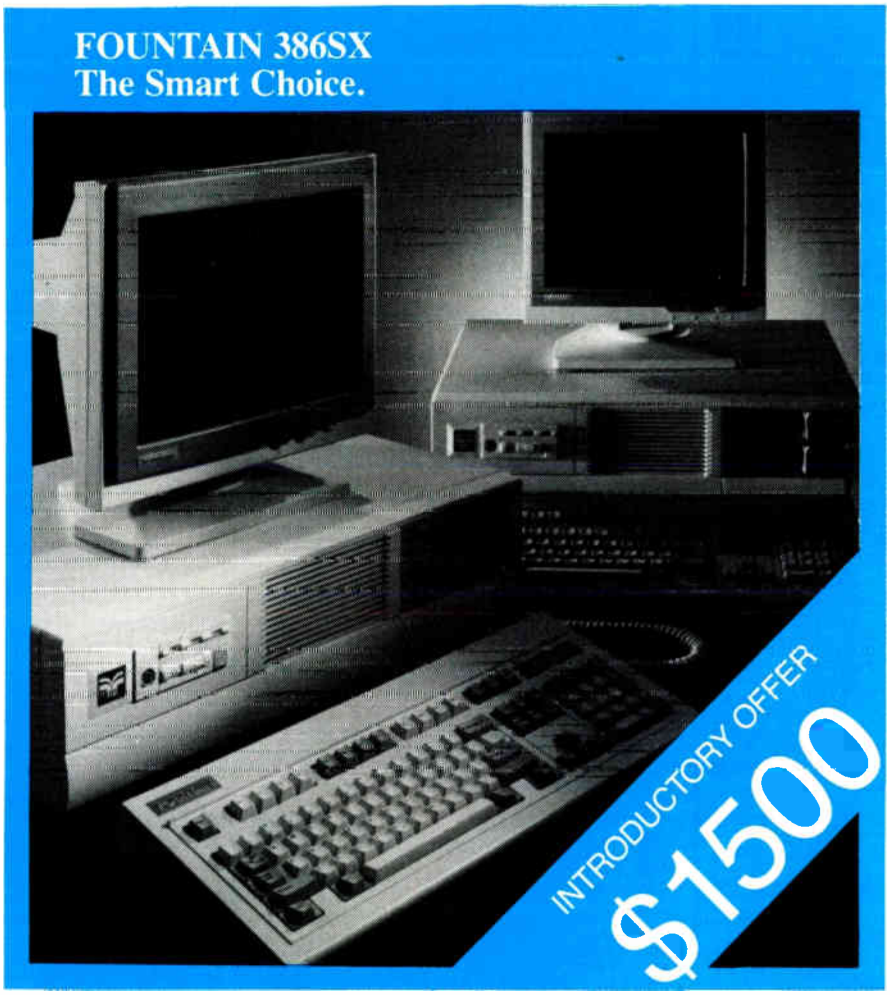

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Circle 558 on Reader Service Card (DEALERS: 559)

Image Processing to Go

Ricoh's Portable Digital Information System gives you image-capture, processing, printing, and faxing capabilities in a briefcase-size package.

The MC50 copier/digitizer is the heart of the system. Within this 12- by 6- by 2-inch self-contained unit is a nickel-cadmium battery, the printing mechanism, and the paper supply. When you digitize an image with the flatbed-type scanner, you make a copy that's 3⅞ by 6½ inches.

You're not limited to thermal paper with the MC50, as with many portable peripherals. In fact, you can also use transparent sheets and plain paper. The MC50's scanning head incorporates a 798-pixel image sensor and produces images with a 200-dpi density and 200-lpi horizontal and vertical resolution.

For scanning into your system, you can buy the 5- by 5- by 1-inch IM-A image controller/scanner module with an RS-232C interface. (It's compatible with XTs, ATs, and Macs.) Its buffer memory is large enough to store a 3⅞- by 6½-inch page, and you can enlarge and reduce the size.

A second peripheral is the IM-F50 fax interface, with Group 3 compatibility and a V.27-compatible (4800-bps, half-duplex) modem. Horizontal and vertical resolution is 200 dpi. It measures 6 by 6 by 2 inches.

Price: MC50, $540; IM-A, $510; IM-F50, $540.
Contact: Ricoh Consumer Products Group, 155 Passaic Ave., Fairfield, NJ 07006, (800) 255-5550, ext. 176.
Inquiry 1010.

The MC50 copier/digitizer can scan images at 26 inches per minute.

Music Notation on the Mac Gets Slimmed Down

Coda Music Software developed MusicProse for musicians who need a music-notation program but don't need all the functions of Finale, the company's high-end program for professional musicians. Like Finale, MusicProse is based on ENIGMA, Coda's proprietary operating system. MusicProse lets you transcribe music into notation via MIDI in real-time mode.

Two other input modes include simple entry, a step-time mode that uses a keyboard and a mouse, and speedy entry, which uses the computer keyboard and a MIDI instrument.

You can use the program to write MIDI files for use in a sequencing program, analyze block chords for accurate chord symbol labeling, automatically align lyrics to note heads, and quickly change key, meter, and clef.

MusicProse works on a Mac Plus with 1 megabyte of RAM and a hard disk drive. The program supports all Imagewriter printers, Coda reports.

Price: $249.
Contact: Coda Music Software, 1401 East 79th St., Bloomington, MN 55425, (612) 854-1288.
Inquiry 1015.

XyWrite III Plus for the NEC UltraLite

XyWrite III Plus is now available on a ROM card that works on the UltraLite, NEC's diminutive laptop computer. The XyWrite ROM card will include all the essential program files, spelling dictionaries, printer files, A La Carte menus, and a keyboard configuration file for the UltraLite.

Other printer files and supplemental files for customizing XyWrite come on two 3½-inch disks. You can load those files into RAM from floppy disks or the UltraLite's hard disk drive. The ROM card, which is about the size of a credit card, also has a file that helps you prepare documents for transmission through the UltraLite's 2400-bps modem.

Price: $445.
Contact: XyQuest, Inc., 44 Manning Rd., Billerica, MA 01821, (508) 671-0888; NEC Home Electronics (U.S.A.), Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
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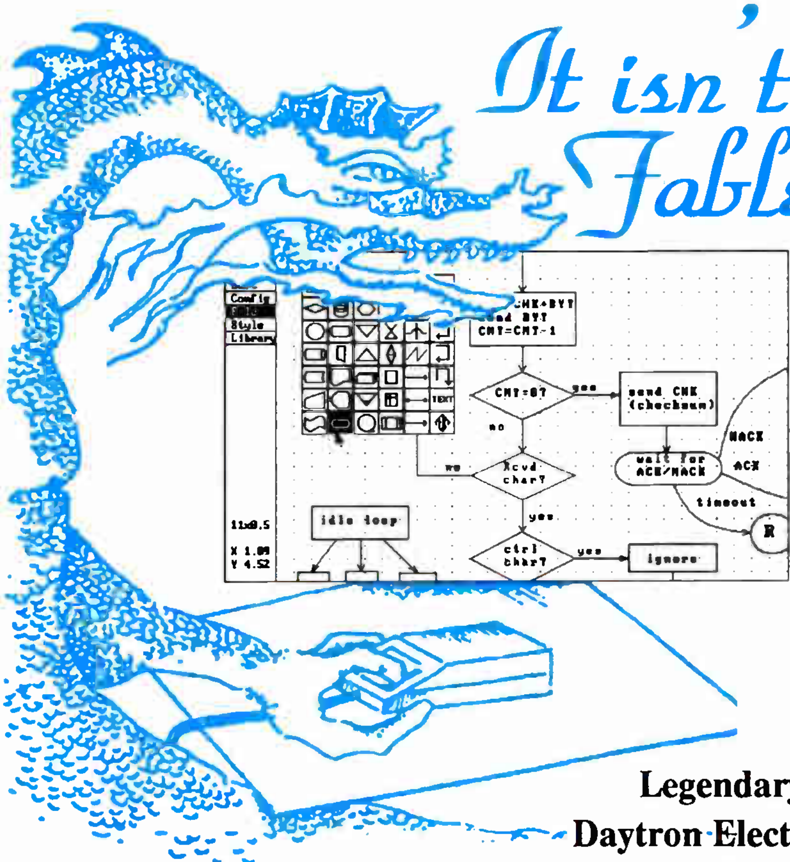

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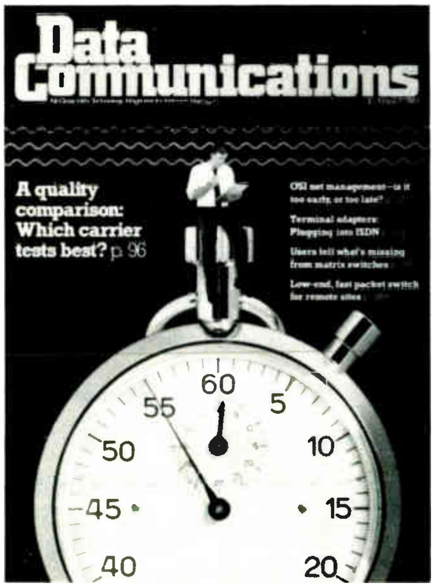

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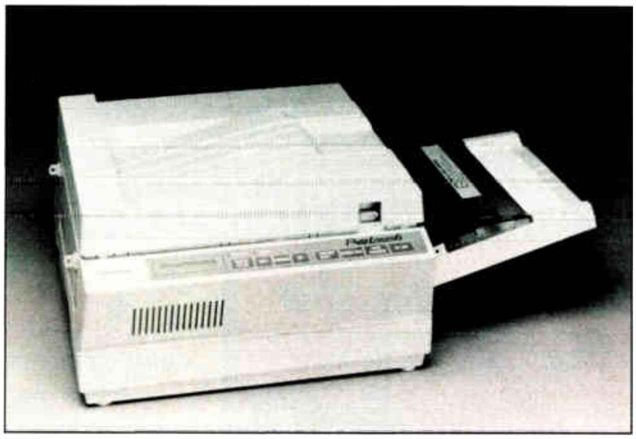

The PageLaser 6's input and output trays have a capacity of 150 letter-size sheets.

PageLaser 6 Features LaserJet Slots

Toshiba's PageLaser 6 weighs 35 pounds, prints 6 pages per minute at 300 dpi, and is priced just under $2000.

The printer features two LaserJet-compatible font slots. The printer's four resident fonts are available in portrait and landscape orientations. It comes standard with 512K bytes of RAM, but you can upgrade to 1, 2, or 4 megabytes.

The toner cartridge and drum are user-accessible, and each cartridge is rated for at least 3000 prints. When you change the toner, you also change a counter in its socket that tells you through a color-coded light whether it's fresh toner, whether you need to order new toner, or whether you're approaching the 3000-sheet limit. Each toner kit includes two 1500-print toner cartridges and one drum-counter key.

Standard emulations include Hewlett-Packard LaserJet Series II and IBM Proprinter XL24. The company says it's working on a PostScript-compatible version.

Price: Less than $2000; toner kit, $49.
Contact: Toshiba America Information Systems, Inc., Computer Systems Division, 9740 Irvine Blvd., Irvine, CA 92718, (800) 457-7777 or (714) 583-3000.
Inquiry 1013.

C Libraries for Multiple Platforms

Vermont Views is a set of C libraries for DOS, Unix, Xenix, VMS, and, soon, OS/2 that were developed to allow portability among operating systems. According to Vermont Creative Software (VCS), you can recompile and relink source code with different versions of Vermont Views with little or no source code modification.

Vermont Views lets you create and manage windows, menus, data-entry forms, text entry, and context-sensitive help. Other features include forms and menus that are bigger than their display windows, automatic scroll bars, horizontally scrollable text fields, scrollable regions for entering variable lines of items, and a mini word processor that you can attach to a field.

VCS reports that it developed the libraries for international portability as well. The programs support any Roman-based language, and the DOS version supports all non-English characters of the IBM Extended Character Set, including utilities to handle uppercase-to-lowercase and lowercase-to-uppercase conversions. You can enter, validate, and manipulate dates and times to accommodate international or military formats, and you can change characters used as decimal and thousands separators.

Price: DOS version, $395 ($795 with full source code); Unix and VMS, $2395 and up; Xenix, $1595; OS/2, $495.
Contact: Vermont Creative Software, Pinnacle Meadows, Richford, VT 05476, (800) 848-1248 or (802) 848-7731.
Inquiry 1021.

Interactive Fiction Videodisk for the Mac

Frame Up places you in the shoes of Eddy, who falls asleep in a department store and wakes to discover he's suspected of burglary. It's your job to get Eddy out of the store before the police arrive or to somehow prove his innocence.

The story's plot isn't unusual for an interactive simulation. What makes Frame Up different is that you prove his innocence by creating a video montage, by editing 10 videotapes that are part of the store's security system. You can view any of the 10 cameras once you get into the control room, or you can play back tapes from 10 VCRs. The tapes are actual film sequences that Imedia International shot to add realism to the program. If you're caught, you're given about 4 minutes to edit the tapes and prove that Eddy is innocent.

The game runs on a Macintosh that's hooked up to a Sony, Pioneer, or Philips industrial videodisk player. The video portion of the program appears in a window, and you make decisions and edit in another window.

Frame Up works on the Mac Plus or higher with HyperCard. Other versions are available for the Amiga and the IBM PC.

Price: $100.
Contact: Imedia International, Inc., 6061 Paseo Canyon Dr., Malibu, CA 90265, (213) 457-8045.
Inquiry 1023.

Statistical Analysis and Probability

Monte Carlo Simulations 2.1 consists of three modules to help actuaries, engineers, and educators compare raw statistical data and produce probabilistic models. The program's simulation module now supports 100 variables per model. New built-in functions include INT, LOG, EXP, and others.

A statistical analysis module lets you compare raw data to 13 probability distributions and use the Chi-Square and Kolmogorov-Smirnov Goodness of Fit tests. Another module lets you create long-term random models, with inflation and other adjustment factors.

The program requires an IBM PC with 384K bytes of RAM, or a Mac Plus or higher with 1 megabyte of RAM.

Price: $395.
Contact: Actuarial Micro Software, The ACS Group, 8025 North Point Blvd., Suite 215E, Winston-Salem, NC 27106, (919) 773-1313 or (919) 759-2013.
Inquiry 1026.

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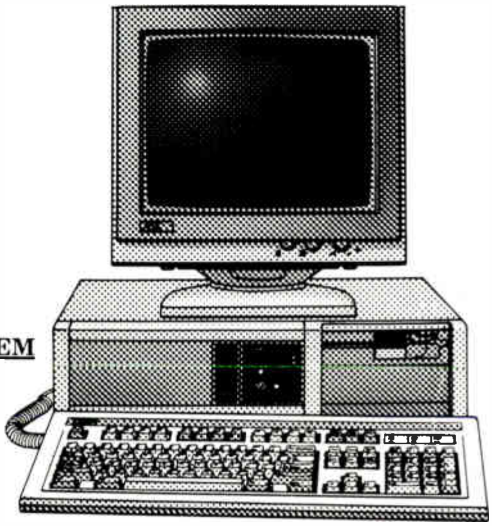

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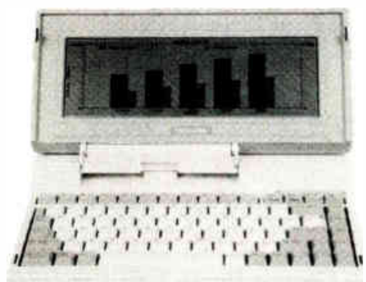

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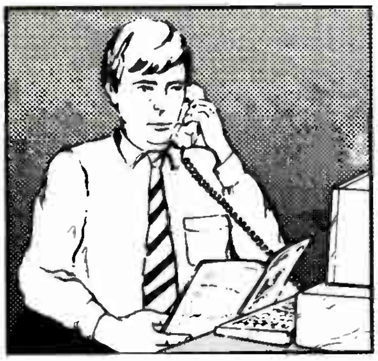

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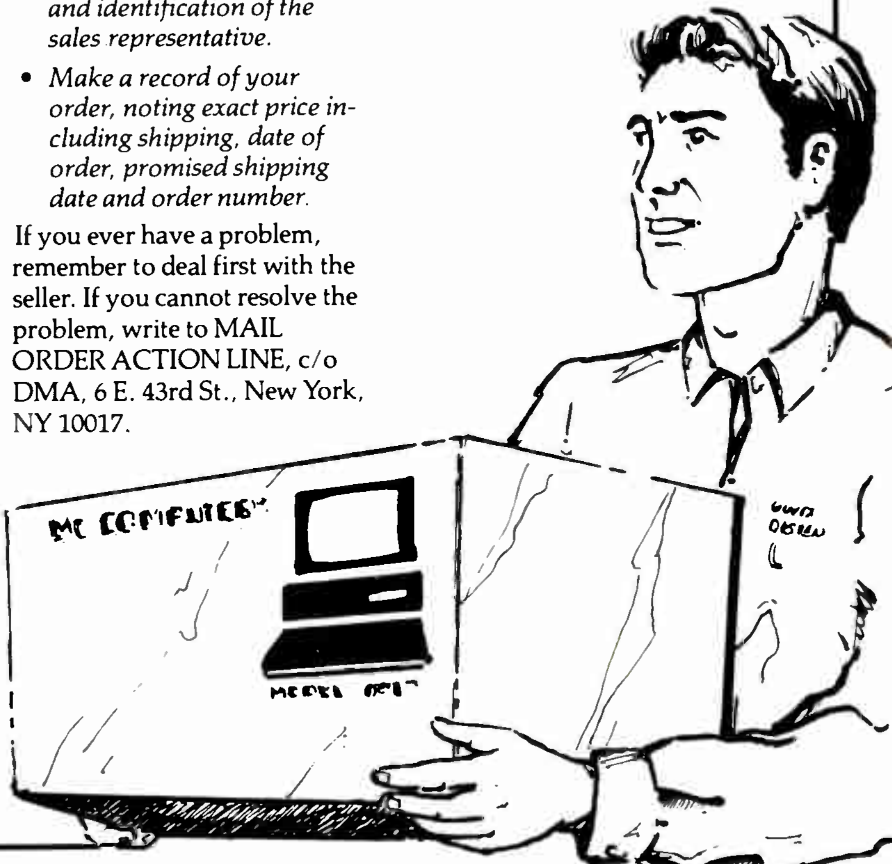

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SHORT TAKES

BYTE editors' hands-on views of new and developing products

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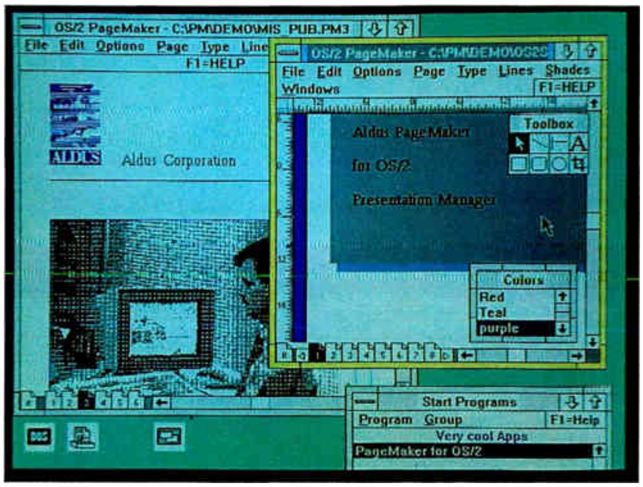

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It may be that for DTP software users OS/2 has found a raison d'être. PageMaker has always been an excellent package, holding a position as one of the two most popular DTP packages for the IBM PC. But I've always thought that it would benefit from a bit more speed, a little less disk swapping, and better font control.

OS/2 provides facilities for managing much more memory than the maximum of 640K bytes handled by DOS. Thus, this version of PageMaker has more memory to use, so it runs much faster than its DOS cousin. Multiple document windows let PageMaker for OS/2 easily transfer graphics elements from document to document. The DOS version has been unable to do this since the conversion from PageMaker 1.0 to 3.0.

OS/2 also fixes something about Windows 2.10 that has always bugged me—the screen fonts. Under Windows, the imprecise font display made it difficult to tell how the printed document would look. You had to trust that PageMaker knew more than it could show you on-screen. I was pleasantly surprised to see how terrific the Presentation Manager fonts looked by comparison. Perhaps I've just never installed Windows fonts correctly, but if that's true, I'm not alone.

Multitasking isn't wasted on PageMaker, either. If you've used PageMaker 3.0, you know what a godsend autoflow was. The ability to automatically run text from one column to another and from one page to another got rid of one of PageMaker 1.0's biggest limitations. But it wasn't the fastest function, and it tied up the computer for a fair amount of time on long text.

Multitasking OS/2 lets the new PageMaker autoflow one document while you work on another. I tested it with a lengthy piece of text and found that I could work smoothly on a second document while the first was still processing.

To make full use of PageMaker for OS/2 right now, you'll have to run under both DOS and OS/2, at least until paint, scanning, and text-editing packages are available for OS/2. This may sound like déjà vu to those of you who remember how frustrating PageMaker was in the early days of version 1.0, when few programs were compatible with Windows.

So, again we must wait. But when the programs are available, PageMaker for OS/2 may be a good enough reason to consider buying OS/2. If you're already running OS/2 and don't have a DTP program, you'll want to give this package a serious look. □

—Howard Eglowstein

Think C Goes OOP

Like fine wine, some Macintosh software gets better with age. So it is with Symantec's C compiler, **Think C**, now upgraded to version 4.0. It uses an integrated development environment that contains an editor, a compiler, and a linker combined in a single application for fast code development. Under MultiFinder, a source debugger lets you step through source code, set breakpoints, and examine the contents of variables, arrays, and structures. So what's new this time around?

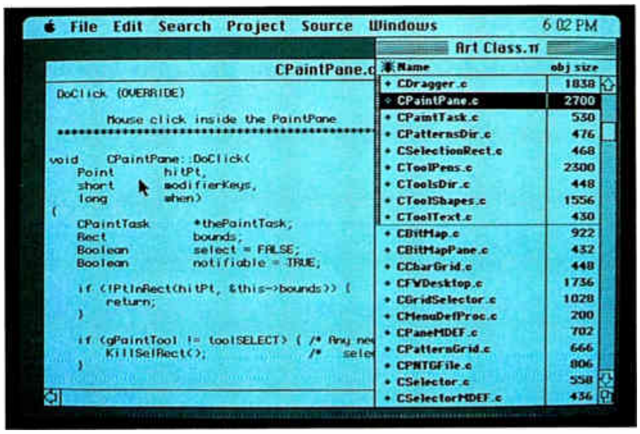
First, the compiler and C libraries now conform to the ANSI standard. Second, the compiler can generate multisegmented code resources (a capability that had been previously limited to applications, drivers, and desk accessories). Third, the compiler's in-line assembler has been

continued

rewritten: The assembly language syntax has been relaxed to support 68020/68030 addressing modes and instructions. The compiler supports the 68881/68882 FPU, but the 68851 paged-memory-management-unit and 68030 MMU instructions are not supported. Last but not least, Think C now supports object-oriented programming (OOP) in language extensions called Object C.

Object C's syntax is loosely based on C++. As with C++, you implement objects by first declaring a *class*. In Object C, these declarations are extensions of `struct` declarations. You allocate or remove objects from memory by using the `new()` and `delete()` functions, respectively. Object C's message dispatcher supports polymorphism; that is, during execution, the dispatcher determines the class of the method that the message is going to (also called run-time binding). This allows you the flexibility to write methods within your program that will override existing methods within a class.

Run-time binding exacts a performance penalty, but the Think C linker looks for ways to overcome this. It evaluates your code, and if a particular method is monomorphic (i.e., it doesn't override another class and is itself not overridden), it generates a direct call to the method, rather than routing it through the dispatcher. A set of class libraries that let you easily use Mac windows, handle the menu bar, and process events is also provided.



THE FACTS

Think C 4.0
$249; upgrade, $69

Requirements:
Mac with 1 megabyte of RAM (2 megabytes and MultiFinder are required to run the source debugger) and System 6.0.2 or higher; a hard disk drive is recommended.

Symantec Corp.
135 South Rd.
Bedford, MA 01730
(617) 275-4800
Inquiry 1003.

The big advantage of Object C is that you can trace through it using the Think C source debugger. You can actually watch the thread of execution pass through objects and see instance variables modified. Two new sample programs (besides the usual application and desk accessory files) are provided: a paint application written in Object C and an object-oriented cdev. Normally, you can use only the source debugger to debug applications, but Symantec also supplies a special application shell that lets you debug a cdev. The preliminary documentation covers only the Unix libraries and Object C extensions. A list of Mac Toolbox calls with the appropriate Think C arguments would be helpful.

I used a prerelease version of the compiler to complete two works in progress. The first was an application that makes extensive use of AppleTalk. The second was an FKEY that output two characters to the Mac's printer port to disengage a smart serial switch I was using to share an Apple ImageWriter with a Mac and a PC.

I had no trouble making the switch to the new compiler and experienced no problems completing the programs. Compiling and linking were snappy, as in version 3.0. I also traced program flow with the source debugger, with both the sample cdev and the object-oriented paint application.

If you already own Think C, it's time to upgrade. If you want a low-cost, fast C development package for the Mac with object-oriented extensions, look no further. Think C continues its reputation as a high-quality product, and its class libraries and source debugger can shed light on how objects *really* work. □

—***Tom Thompson***

An Ink-Jet Printer for the Mac

Macintosh users now have an ink-jet printer to call their own. The **DeskWriter** from Hewlett-Packard is the new Mac printer that's based on DeskJet technology.

Using a relatively simple paper path, ink is deposited at a rate of 300 dots per inch from a disposable ink cartridge. The cartridges are priced at a reasonable $18.95. However, if they last only as long as those in the DeskJet Plus, you'd better buy a handful.

You can increase the print speed up to 50 percent with the draft-quality mode, which prints at 150 dpi.

This 15-pound printer is powered by an external power supply from an AC outlet. To hook it up, you'll need an M0197 Apple male-mini-8-to-male-mini-8 cord, which you connect to the serial port of your Mac.

The printer uses QuickDraw to do its imaging and has a driver from Palomar Software. You can scale the fonts from 4 to 250 points without having to install fonts for each point size. While this is similar to the printing mechanism envisioned in Apple's forthcoming System 7.0, it remains to be seen what effect the release of System 7.0 will have on the printer driver. It will probably be minimal, since the overall design appears to conform to Apple guidelines.

THE FACTS

DeskWriter
$1195

Requirements:
Mac Plus, SE, or II with a hard disk drive for font storage and a standard peripheral/8 cable.

Hewlett-Packard Co.
19310 Pruneridge Ave.
Cupertino, CA 95014
(800) 752-0900
Inquiry 1004.

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> —*Jerry Pournelle*, Byte Magazine, *Sept. 1989*

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capabilities for saving files to certain formats before investing in an FDHD unit or DOS Mounter.

The package comes with an "extension mapping" feature that lets you open a DOS file by just double-clicking on the file's icon instead of having to first call up the application. This feature basically links DOS file extensions with Mac applications, like DBF with dBASE Mac.

The program's extension table is set up for common programs like dBASE, Excel, and PageMaker. You can customize this table in a window that's similar to the Font/DA Mover. Extension mapping doesn't eliminate the need for file translation when working with incompatible files or programs. Mapping a DOS file to an incompatible Mac program will result in either the program not starting up or the file containing weird characters.

DOS Mounter cannot initialize or erase DOS disks. For that you need the Apple File Exchange 1.1.1, which comes with DOS Mounter. You're supposed to be able to initialize disks in either 720K-byte or 1.44-megabyte formats, but the version that I worked with didn't have a button for the higher density.

I took some disks formatted in the FDHD unit and tried using them with several different DOS computers. I thought that my skepticism was justified when a certain PC clone wouldn't have anything to do with one of the Macintosh-born disks, but it turned out that the clone had some bad parts and wouldn't even accept true-blue disks.

If you're a Mac user who's frequently working with data files from a DOS computer and you like convenience, you need an Apple FDHD unit. And if you need an FDHD unit for your Mac, you probably also need the DOS Mounter software. □

—D. Barker

THE FACTS

DOS Mounter
$89.95

Requirements:
Mac with an FDHD unit and System 6.0.2 or higher.

Dayna Communications
50 South Main, Suite 530
Salt Lake City, UT 84144
(801) 531-0600
Inquiry 1006.

Cold Cache for Your Hard Disk

Caching disk controllers, which use dedicated RAM to store most-often-used data for virtually immediate access, have been available for several years. But the last few months have seen the arrival of a new generation of "smart" caching controllers that put a big dent in the hard disk drive data transfer bottleneck.

Two such controllers are **hyperStore-816** from Perceptive Solutions and **SmartCache PM3011** from Distributed Processing Technology (DPT). Starting with a 10-MHz IBM PC AT clone, I used both controllers with a Seagate ST577R 64-megabyte run-length-limited (RLL) hard disk drive. The results were impressive.

Of the two, the hyperStore-816 has the more radical design. It's a full-length single-slot caching controller that includes a custom hard disk drive BIOS and its own operating system controlling a dedicated Zilog Z80280 microprocessor. Cache RAM is neatly packaged in single in-line memory modules. Although

continued

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Circle 203 on Reader Service Card

512K bytes is standard, the unit I tested was packed with the maximum of four 1-megabyte SIMMs.

Perceptive Solutions puts its standard floppy disk drive controller and the hard disk drive interface modules on small daughterboards that are mounted to the main hyperStore-816 board. This perceptive design lets you easily change the hard disk drive interface (RLL, modified frequency modulation, ESDI, or SCSI) should you upgrade your hard disk drive.

DPT's SmartCache has a Motorola 68000 microprocessor and uses a more conventional design, with the (optional) floppy disk drive controller and hard disk drive interface integrated onto a single board. This can be a real pain if you change to a drive with a different interface, requiring you to buy an entire new controller. If you want to use a larger cache than the standard 512K bytes, you also need to add a second full-size board. DPT uses standard 1-megabit chips; the board can hold up to 12 megabytes.

After making a full backup of my drive, I found both boards easy to install.

After DOS partitioning and formatting the drives, I immediately booted and used the system in the normal manner. The increase in performance was dramatic. Objective benchmarking of these boards is almost impossible, because the jealously guarded proprietary algorithms "watched" how I worked and became progressively faster as I used them. Both companies claim an effective disk-access time of about 0.5 ms, and I have to agree. What this means in real-world terms is that most applications run eight to 12 times faster.

Although both boards gave me similar results, each had idiosyncrasies. I liked the compact design and easy expandability of the hyperStore-816, but the unit I tested worked only with vanilla DOS. (The company says that drivers for Unix, OS/2, and Novell NetWare are on the way.) SmartCache works with all operating systems, but the necessity of using a second slot for additional cache memory is inconvenient. In addition, my SmartCache ran very hot, although the company assured me that it was normal. Although fully configured caching controllers are not inexpensive, I found that the real speed they added to my system is a better investment than a faster microprocessor. ■

—Stan Miastkowski

THE FACTS

hyperStore-816
$1195 (with 512K bytes)

Requirements:
IBM AT or compatible.

Perceptive Solutions, Inc.
1509 Falcon St.,
Suite 104
DeSoto, TX 75115
(800) 343-0903
Inquiry 1007.

SmartCache PM3011
$1150 (with 512K bytes)

Requirements:
IBM AT or compatible.

Options:
Floppy disk support, $80; mirroring option, $800; BIOS expander chip set, $50.

Distributed Processing Technology
132 Candace Dr.
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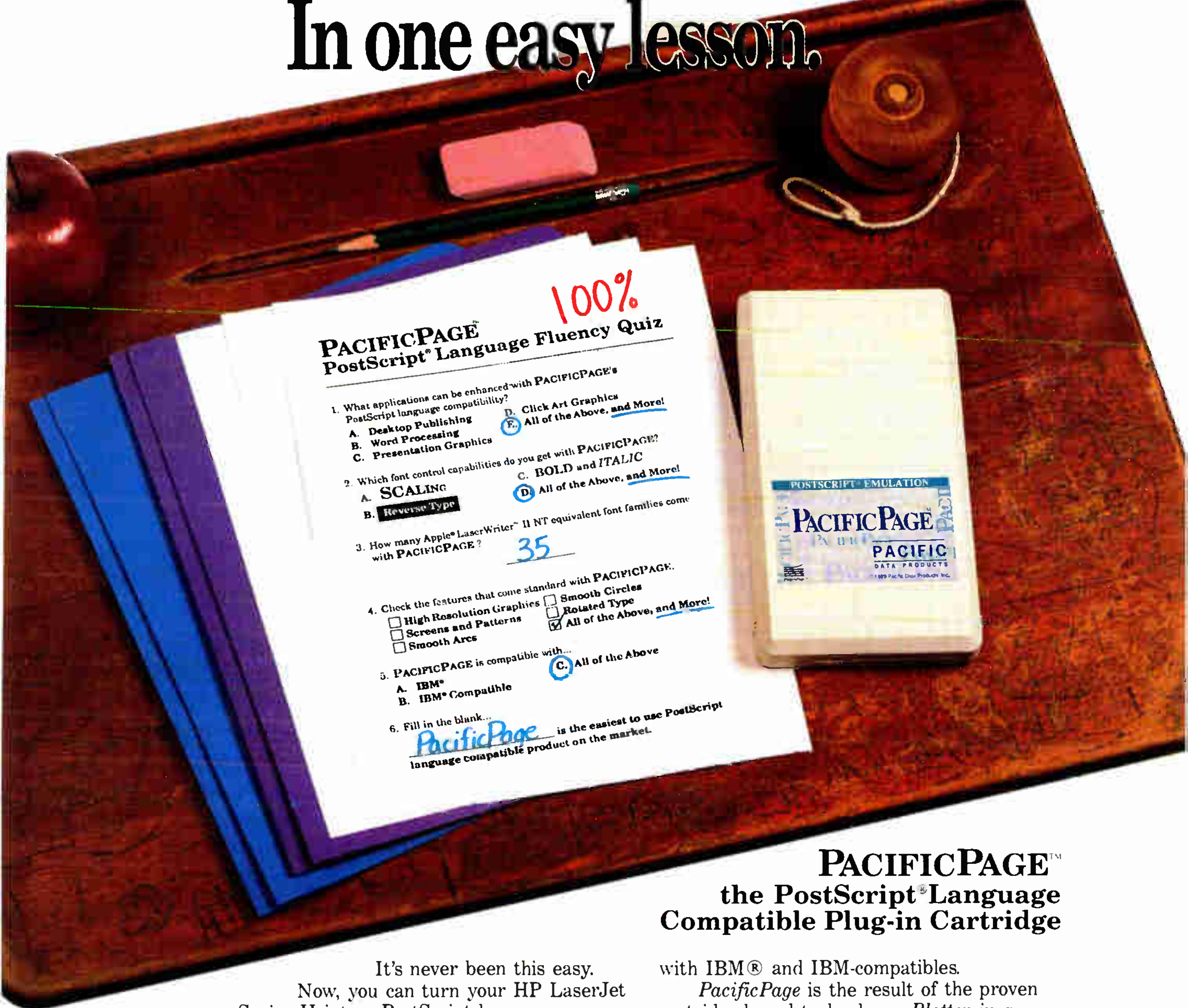

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PC Magazine, May 30, 1989

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ZEOS 386/16 Desktop	3.58	13.62	0.58
ZEOS 386/20 Desktop	2.87	10.82	0.38
IBM PS/2 Model 70-E61	4.08	16.04	0.75
Compaq Deskpro 386/16	4.12	15.47	0.75

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ZEOS 386-16 PC MAGAZINE EDITOR'S CHOICE 2-26-89

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ZEOS 386/33 Desktop	1.67	6.43	0.27
IBM PS/2 Model A	2.27	8.33	0.60
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The Portable and

Apple introduces a portable Macintosh line and its newest high-performance modular Macintosh

Apple has finally entered the portable computer sweepstakes with its introduction of the Macintosh Portable, a hefty wedge of computing power that's all Macintosh. At the same time, Apple announced the most powerful Macintosh ever: a high-speed muscle machine called the Mac IIci that rewrites the rules on limits to the Macintosh computer.

The long-awaited Macintosh Portable isn't a laptop—measuring nearly a foot and a half on each side and weighing in at roughly 16 pounds, it won't fit comfortably on your lap. But the Portable still lives up to its name: It can operate for up to a full working day away from a power outlet, its razor-sharp reflective LCD screen sports more pixels than the Mac SE's screen, and it includes a built-in trackball that replaces the mouse. It's a fully functional Macintosh, using a 16-MHz 68000 processor and enhanced Mac SE ROMs.

The high-powered Mac IIci looks like the twin of its six-month-old cousin, the Mac IIcx. But a closer look reveals a video connector on the back, hinting at the changes inside. Internally, the Mac IIci has been completely redesigned, using a 25-MHz 68030 processor, a much improved memory subsystem with faster memory, and a slot for a memory cache board.

the Powerful

Mac Portable: An Outside Tour
With its tilt-up display stowed, the Portable resembles a wedge 15¼ inches wide by 14⁵⁄₁₆ inches deep that's taller at the back (about 4 inches high) than at the front (about 2 inches high). Its outer shell is made of high-impact platinum-gray plastic.

The Portable comes out of the box packed in its carrying case. If the unit has a hard disk drive, the system software is preinstalled. A built-in handle running the width of the wedge's shorter end pops out to make carrying the computer easier. To open the unit, you push the handle back into the wedge's body until the top of the case unlatches. The hinged casetop contains the display, and it uncovers a full-size keyboard with 63 keys. The hinge has a friction clutch so that you can adjust the display to any angle.

To the right of the keyboard is a miniature (1⅓-inch-diameter) trackball that replaces the mouse as the pointing device. Beneath it is a large button that serves as a mouse button. For the purists, a single Apple Desktop Bus (ADB) port at the rear allows use of a low-power mouse.

All other Macs have two ADB ports (except the Mac Plus, which doesn't use the ADB for its mouse/keyboard connections), but since the Portable's keyboard and trackball use internal ADB connections, the missing second ADB port isn't a problem. You can use a conventional ADB mouse, but it consumes more power and will shorten the Portable's operating time. If you're using an external mouse, you can replace the trackball with a numeric keypad.

Apple has a knack for handling fine details, and one place where this shows is in the trackball/keyboard design. Both the keyboard and the trackball can be popped out of the chassis and swapped so that the trackball is to the left of the keyboard, making it more convenient for left-handed users. (See photo 1.)

A 1.4-megabyte 3½-inch FDHD "SuperDrive" reads Mac, Apple II, or DOS-compatible 3½-inch floppy disks. The FDHD is located toward the back of the Portable, on the right side. At the rear are the usual I/O ports and several new connectors: a video port, an RJ-11 connector for an optional internal modem, and a battery charger connector. The external battery charger can operate in the 70- to 270-volt range and can handle frequencies of 40 to 70 Hz. This makes the battery charger usable anywhere in the world, provided you have a connector for the wall outlet conductors.

The Portable's display is a 9⅘-inch-diagonal flat-panel screen that uses a reflective, active-matrix, LCD technology to provide a 640- by 400-pixel black-and-white display in which every pixel is controlled by a separate transistor. By comparison, compact Macs have a 9-inch-diagonal screen with a 512- by 342-pixel display, and modular Macs using a Macintosh II video board have a 12- or 13-inch-diagonal screen (depending on the monitor type) with a 640- by 480-pixel display.

The Portable is the first computer to use the active-matrix LCD. This technology provides the high contrast and high response speed required to display the mouse pointer in real time. Two other significant advantages of this

continued

display are its low power consumption and wide viewing angle. The video port supplies only LCD signals; an optional adapter converts these signals into analog signals for a Mac monochrome monitor or into National Television System Committee, PAL, or Séquentiel à Mémoire (SECAM) video signals.

You switch on the Portable by hitting any key on the keyboard. It has no cooling fan since it consumes so little power (1 watt without a hard disk drive and 3 W on average when the hard disk drive is running).

Mac Portable: The Inside Tour

The Macintosh Portable's ancestry can be traced to the Mac SE. However, the two computers differ as markedly on the inside as they do on the outside. Interestingly, the Portable's designers have packed more functions and slots into the smaller system.

Photo 2 shows the Portable motherboard. Its heart is a low-power CMOS 68000 processor beating at 15.67 MHz—twice the speed of the Mac SE. The 256K bytes of ROM contain enhanced Mac SE firmware that incorporates bug fixes to existing Mac SE ROMs, the LCD driver, and new functions that manage the Portable's power use. Sound generation is much improved because the Portable uses the same Apple Sound Chip (ASC) found in the Mac II to generate stereo sound.

The system comes equipped with 1 megabyte of 100-nanosecond static RAM (SRAM). A 50-pin RAM expansion slot lets you expand system RAM via a 1-megabyte RAM board, for a total of 2 megabytes. When higher-density RAM becomes available, future RAM boards will expand the Portable's maximum memory to 9 megabytes. A 50-pin ROM expansion slot either provides for a possible ROM upgrade (by moving the appropriate jumper—the Portable addresses the ROM slot rather than on-board firmware at boot-up) or allows a vendor to install up to 4 megabytes of embedded software. This latter capability would be useful, for example, to salespeople who need custom software to access on-line databases or to process forms.

Like the Mac SE, the Portable also contains a Processor Direct Slot that provides unbuffered CPU signals for use by hardware expansion boards. Although this slot uses the same 96-pin Euro-DIN connector as the Mac SE, it's incompatible electrically because of differences in the processor speed, power consumption, and additional control signals. The Portable, unlike the Mac SE, has no external access port for the PDS.

As if enough hardware wasn't packed in there already, the Portable also has a slot for an optional 2400-bps modem board and room for an optional one-third-height 40-megabyte 3½-inch SCSI hard disk drive. (See photo 3.)

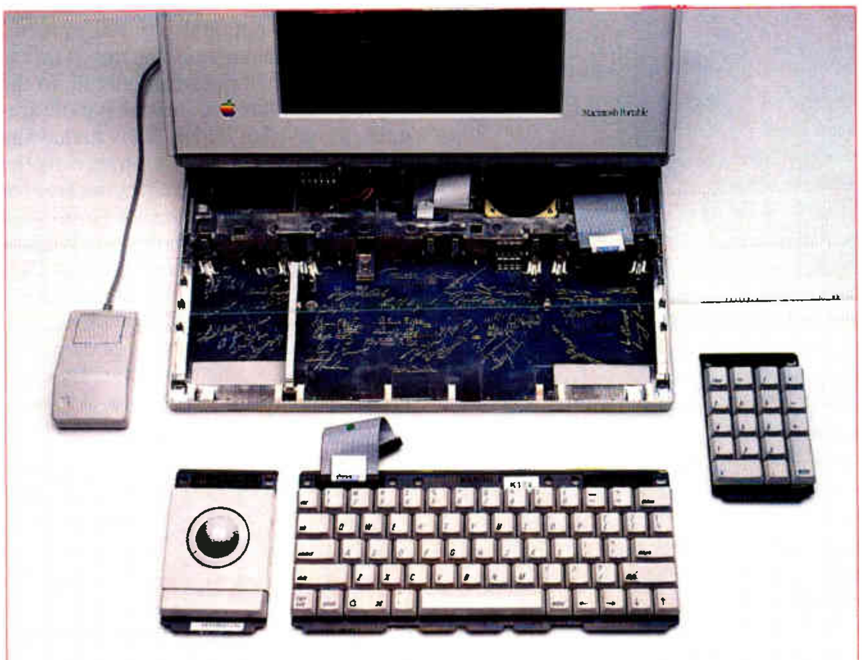

Photo 1: *The keyboard and the trackball can be removed and swapped to accommodate left-handed users. Mouse users can replace the trackball with a keypad.*

Conserving Energy

To get the most out of the system, you need a reliable power source. A 2-pound, 6-V, lead-acid gel battery supplies the Portable's 5-V power. Apple chose lead-acid batteries over other battery technologies for several reasons. First, the technology is a proven one. Second, the battery voltage varies slightly as it is discharged. This gives a rough indication of the battery's remaining power—unlike a nickel-cadmium battery, whose voltage drops only when its power is nearly exhausted. Third, a lead-acid battery can be completely recharged from any level of discharge, while a nickel-cadmium battery must be discharged completely before it can be fully recharged.

Wherever possible, Apple used low-power CMOS components in the Portable. Since a CMOS version of the 68030 processor was not available, that processor was not used; it would have consumed far too much power. The main memory's SRAM eliminates the need for memory refresh circuitry. The reflective LCD uses little power, and none is spent backlighting the screen. The Portable's SCSI hard disk drive was selected for low power consumption and its ability to be switched on and off frequently.

However, even these measures aren't enough. The Portable uses a dedicated processor termed a "power manager" (not to be confused with the software Managers present in the Mac ROMs) that actively regulates power in the computer. The power manager is a Mitsubishi 50753 processor, and it primarily provides "hooks" that the System software can use to switch various subsystems on or off as needed. The power manager accomplishes this by either disabling the clock signals to various components (e.g., the Standard Wozniak Integrated Machine [SWIM] chip and the serial communications controller [SCC] chip) or switching off the power to the hard disk drive.

If a certain subsystem is inactive for a predetermined amount of time, the power manager shuts it off. Likewise, if application software is going to write to an inactive device (say, the hard disk drive or the serial port), the device driver turns the subsystem on. The power manager also takes over the duties of parameter RAM, manages the real-time clock, and serves as an ADB transceiver. It also monitors the battery voltage.

The Portable operates in several modes, each using a different amount of power. In the *active mode*, the Portable operates at 16 MHz and uses the most power. If the system sits idle (i.e., no user activity and no I/O in progress) for more than 15 seconds, the Portable enters a power-saving *rest mode*. In this mode, additional wait states (64 per bus cycle) are added to each RAM or ROM access. This slows the Portable's effective speed to 1 MHz and reduces the power consumption of the processor and memory subsystem by 20 percent.

If the Portable continues to remain idle for over several minutes (the exact interval is user-selectable from a Control Panel cdev), it enters a low-power *sleep mode*. To enter this mode, the power manager first saves the state of the 68000 processor and certain system variables. Then the CPU, display, and many of the peripheral subsystems are turned off. Finally, the power manager switches itself off by disabling its own 3.9-MHz clock. The SRAM and video memory remain powered, preserving their contents. Also, portions of the modem board and several chips (i.e., the Versatile Interface Adapter, the SCC, and the keyboard processor) remain powered.

A clock signal reactivates the power manager every sixtieth of a second, and it evaluates the situation to see if the Portable should "awake" into active mode. Several conditions can terminate the sleep mode. One is hitting a key; this closes a gate that a keyboard processor detects, and it in turn notifies the power manager. Since the ADB circuits are inactive in the sleep mode, moving the trackball or clicking the mouse button will not awaken the system.

By saving the system's state and preserving main memory, these actions "freeze" the state of a running application when the Portable enters sleep mode. When the power manager restores the Portable to active mode, the application resumes from the point at which it stopped.

In another example of Apple's attention to detail, you can also set a predetermined wake-up time for the power manager. This way you can set the Portable to wake up at night and have a suspended telecommunications application start executing a script to log onto an on-line information service. Better still, the modem board's ring-detect circuitry remains powered, so that an incoming call to the Portable's modem can wake up the system, and it can resume running, say, an application to receive E-mail or a report.

The Portable presents you with several alert boxes as the battery's power diminishes. The first alert box appears when

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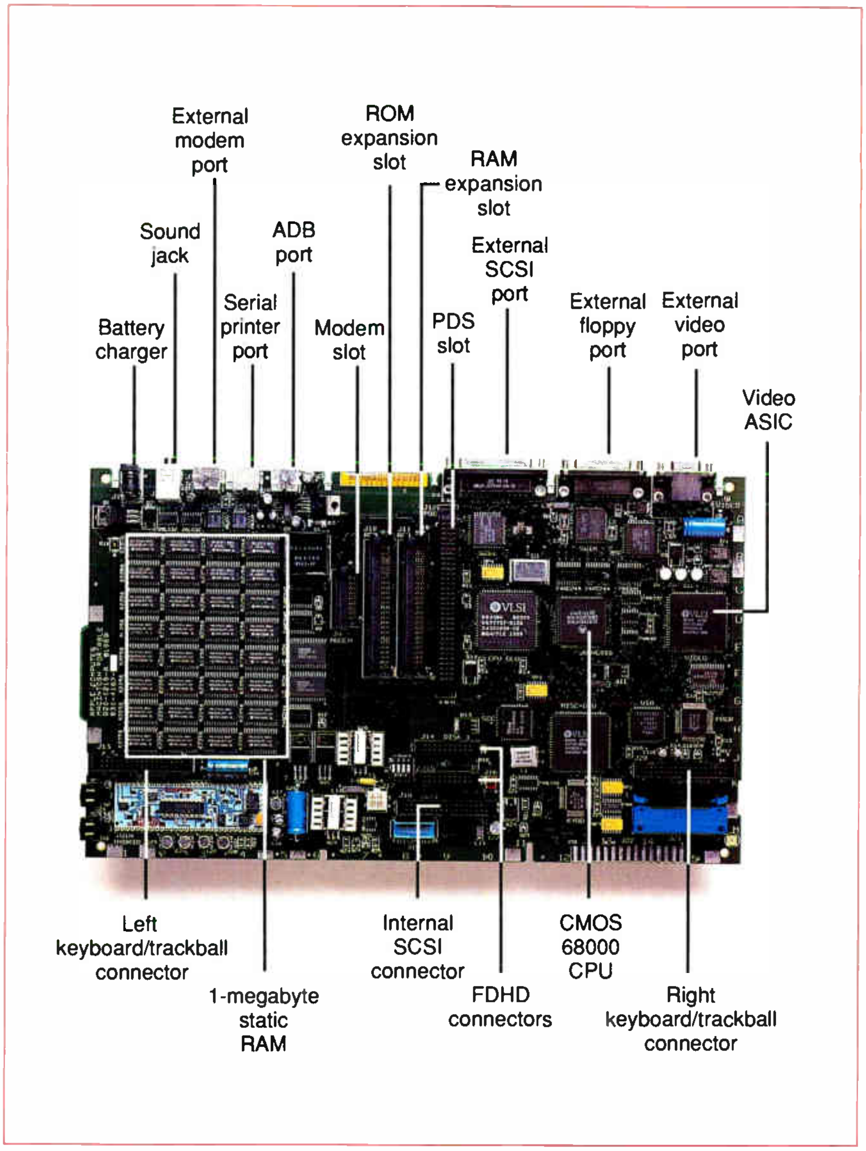

Photo 2: *The Mac Portable motherboard. It uses CMOS components to reduce power consumption. The 68000 CPU runs at 15.67 MHz, twice the rate of a Mac SE.*

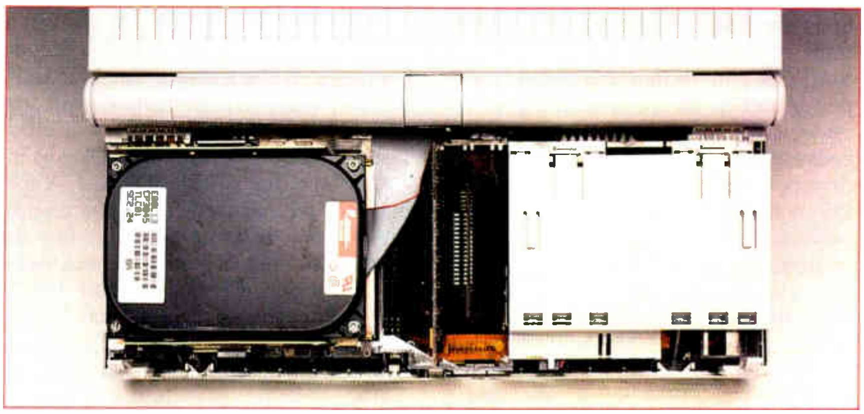

Photo 3: *Inside the Portable. At left is an optional 40-megabyte SCSI hard disk drive; in the center are RAM/ROM expansion slots; to the right is the battery housing.*

there is roughly an hour of battery life left (the exact interval depends on the Portable's configuration and usage). It tells you that you are running on reserve power and warns you to recharge the battery. The second and third alert boxes appear when the battery is at 50 percent and 25 percent of this reserve capacity. When the power level becomes critical, the Portable automatically puts itself into sleep mode. The battery preserves the state of the machine and memory for about four days thereafter. You can run the Portable while recharging the battery, or, if you need to swap batteries, a conventional 9-V battery energizes the system long enough for you to make the exchange.

Software Considerations

The Portable runs System 6.0.4, which is required to deal with the new hardware in the computer. A `Portable` cdev lets you adjust the LCD's contrast, time-out intervals for entering the sleep mode and switching off the hard disk drive, wake-up time, and whether to use the internal modem or an external modem via the serial port. You can also set the size of a RAM disk so you can operate out of RAM rather than use a power-hungry hard disk drive. As a safeguard, the rest mode can also be disabled.

The Finder's Special menu has a new item: `Sleep`. On the Portable, only minor differences exist between `Shut Down` and `Sleep`. Both power down the computer, but `Shut Down` closes all active applications while `Sleep` only suspends them.

Naturally, there are the usual concerns about software compatibility with this new Macintosh. Anything that addresses the serial ports directly (some MIDI applications) or the ADB hardware will break, since that particular I/O subsystem might be switched off. Applications should use either the appropriate traps or the serial drivers, so that the Mac OS can switch the subsystem's power back on before performing the operation. Sound generation is a problem because in many cases the old sound drivers were accessed directly. The Mac OS monitors the ASC for accesses and powers on the chip as required. Newer applications should use the Sound Manager whenever possible.

Applications that perform lengthy calculations must take precautions to prevent the Portable from entering the rest mode and lengthening the process—a distinct possibility if the operation takes more than 15 seconds. This problem has an easy fix: The Portable won't enter rest mode if the mouse pointer is a stopwatch icon, normally indicating a time-consuming process. Most applications already use either the watch or the MPW "beach ball" to indicate that the application is busy, so this shouldn't be a problem.

Finally, software designers should beef up their error checking, since the user can put the Portable into sleep mode at any time and the rest mode can produce significant delays. Both actions can produce new and unanticipated errors.

The Mac IIci

The Mac IIci is Apple's newest high-performance member of the modular Macintosh line. The Mac IIci's outside looks almost identical to that of the Mac IIcx, down to the same compact case, but it has a faster CPU and a completely redesigned motherboard.

> *The Mac IIci goes a long way toward using all the features of the 68030 processor.*

Like the Mac IIcx, the Mac IIci uses a Motorola 68030 processor and a 68882 FPU, three NuBus slots, and a 3½-inch FDHD drive. It also has the IIcx's collection of I/O ports: two ADB connectors, a DB-25 SCSI connector, an external floppy disk drive connector, two mini-DIN-8 serial ports, and a stereo sound connector.

But here the resemblance ends. The Mac IIci's CPU and FPU are clocked at 25 MHz rather than 16 MHz—a 56 percent jump in clock speed. The Mac IIci's memory subsystem is beefed up in several ways. First, the memory itself is faster, using 80-ns fast-paged DRAM instead of the IIcx's 120-ns DRAM. A special slot for memory-cache boards provides direct memory caching. For the first time, memory parity-checking is also an option. Using 4-megabit-density RAM mounted in single in-line memory modules (SIMMs), you can expand the Mac IIci's memory to 32 megabytes.

The Mac IIci also has an on-board video subsystem that generates monochrome or color signals through a standard DB-15 video port on the computer's back, and user-selectable screen depths of 1 (black-and-white), 2, 4, or 8 bits (gray scales or 256 colors). The maximum screen depth is 4 or 8 bits, as determined by the monitor type.

Last, but certainly not least, the Mac IIci now has new 512K-byte ROMs for system firmware, as opposed to the Mac IIcx's 256K-byte ROMs.

Engineered for High Performance

The real star of the show is the Mac IIci's new, faster processing core (see photo 4). The 25-MHz 68030 and 68882 and the 80-ns memory mean that software runs faster. But the supporting cast is critical, too: You can't just drop a faster processor and memory into any computer, least of all a Macintosh. Unless you're planning to redesign every peripheral in the system, the other timing functions—such as those for the serial ports, the FDHD controller chip, and the ADB controller—must remain the same.

The Mac IIci's design team elegantly solved the problem by decoupling the processor and memory clock speeds from the clock speed of the I/O subsystems. Earlier members of the Mac II family used a single oscillator to generate a clock signal that was then divided into signals for the CPU and other subsystems. (A separate oscillator generates the 10-MHz NuBus clock.) Attempting to boost the clock speed of this type of design triggers a cascade of modifications. Therefore, the Mac IIci uses a separate oscillator for the CPU and memory, another for the various I/O subsystems, and still another set of oscillators for running the on-board video. As a result, future Macs will be able to run still faster processors without major revisions to the overall design.

The Mac IIx and IIcx failed to use all the features of the 68030 processor. The IIci goes a long way toward filling that gap. First, it uses the 68030's burst access mode, which allows the CPU to read 16 bytes of data at a time in about half the clock cycles. The result is another 10 percent improvement in performance.

Along with faster DRAM, the Mac IIci also includes a 120-pin connector for a user-installed direct memory cache board. In a direct memory cache, cache memory is a simple mirror image of a section of memory (unlike the more complex *set-associative* caching systems commonly used on PC-compatible machines). As a result, the Mac IIci's cache may have a somewhat lower "hit rate" (i.e., how often the required data is actually in the cache; on a "cache miss," the

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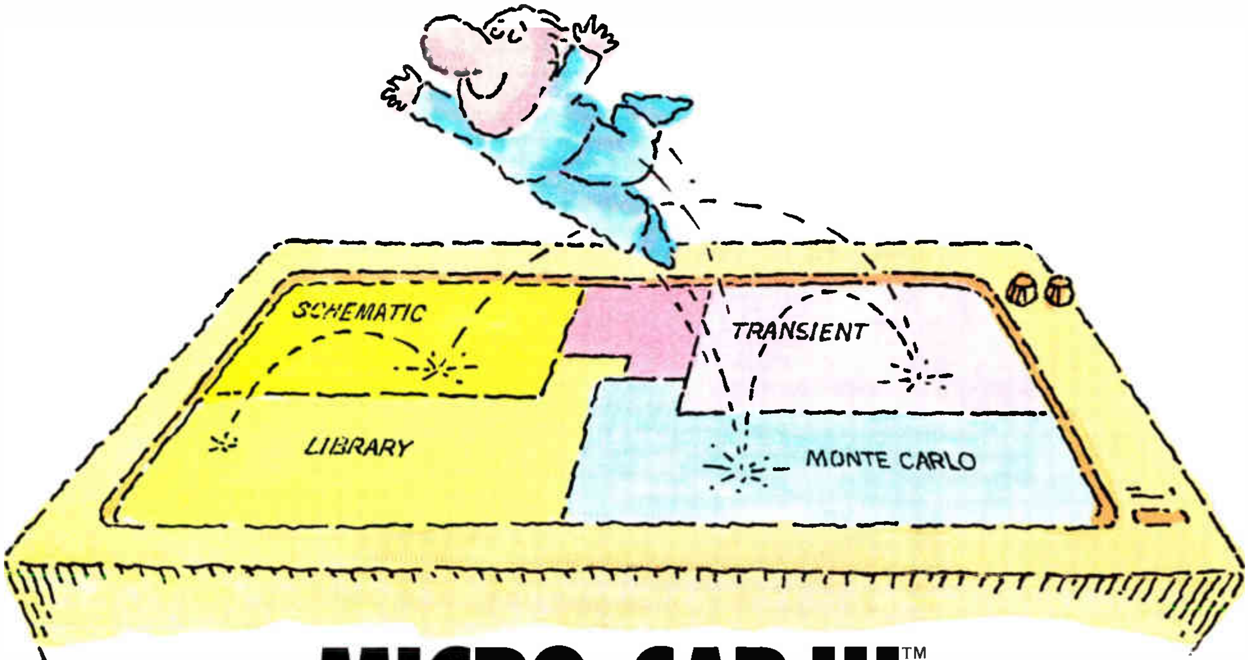

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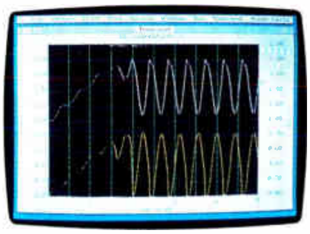

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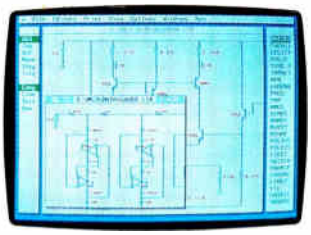

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Circle 258 on Reader Service Card

CPU must wait a little longer while the data is fetched from main memory).

Apple is working on its own direct-memory cache board, but it won't be available until next year. Apple claims that the Mac IIci normally operates 45 percent faster than a Mac IIcx, and with a cache board, up to 55 percent faster.

Built-in Video

Perhaps the most unique feature of the Mac IIci is the video subsystem built onto the motherboard. It supports a 640- by 480-pixel display that can be 1, 2, 4, or 8 bits deep and is functionally equivalent to a Macintosh II video board. It also supports Apple's Portrait Display monitor with a 640- by 870-pixel display at screen depths of 1, 2, or 4 bits, which ordinarily would require yet another NuBus video board to use.

No special installation is required to use the video: You simply plug an Apple monitor into the Mac IIci's video socket and start the computer. The Mac IIci automatically configures the system to drive the monitor. The Start Manager (software used to run hardware diagnostics, initialize the system, boot from a start-up drive, and then launch the Finder) examines three lines on the video connector. If a monitor is attached, certain combinations of these lines will be grounded, and the Start Manager knows to use the on-board video subsystem. The grounding pattern identifies the type of monitor connected to the system.

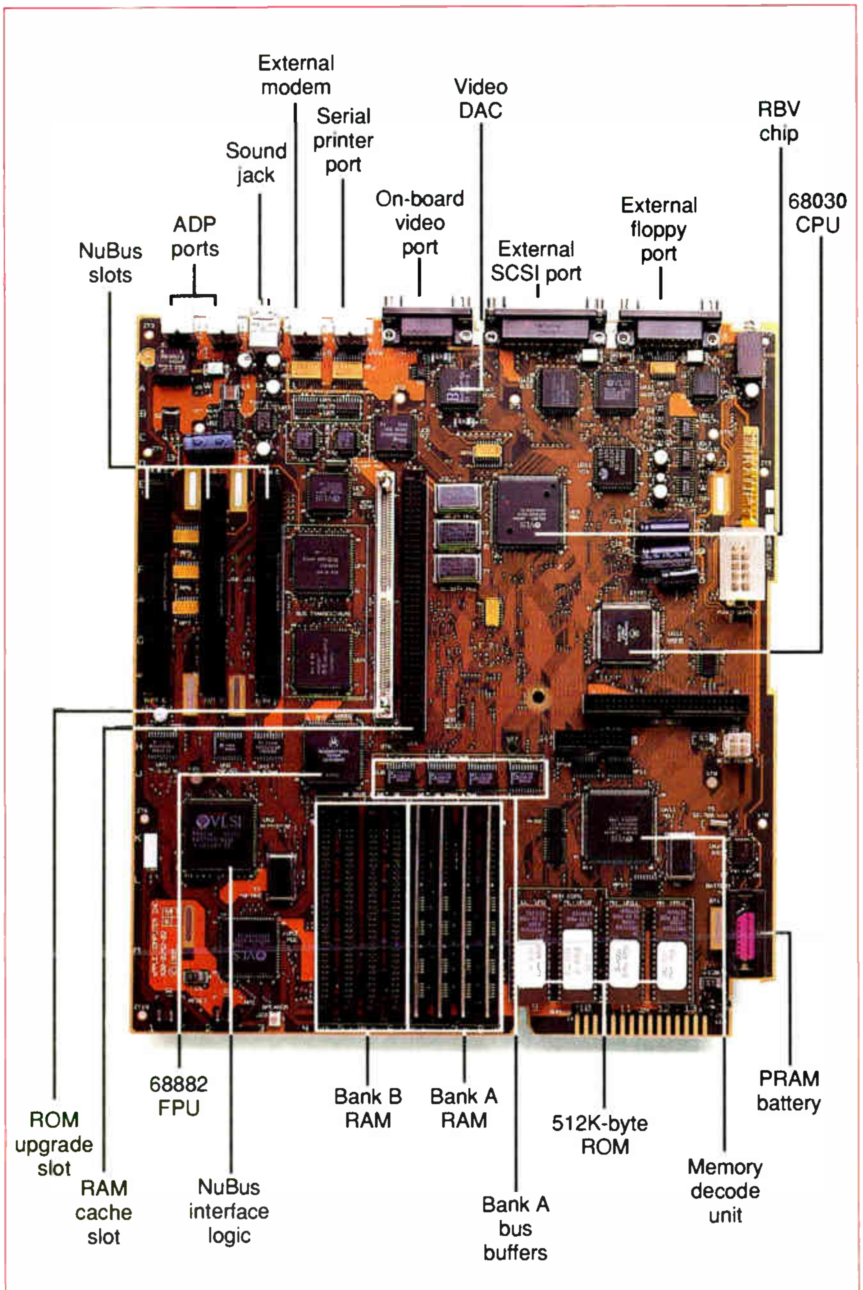

Photo 4: *The Mac IIci motherboard. The various application-specific ICs reduce the board's component count and thus improve its reliability.*

This built-in video accomplishes two purposes. First, it means a price reduction, since—unlike the rest of the Mac II family—it's no longer necessary to buy a video board to use the Mac IIci. Second, this frees up one of the three NuBus slots that the video board normally occupied. The Mac IIci still supports NuBus video boards if your application requires it (e.g., for 24-bit color) or if you add a second monitor.

The Mac IIci's built-in video provides a significant jump in video performance. This is because a section of ordinary system RAM, rather than video RAM on a NuBus board, is used for the video frame buffer. The 68030 can put video information directly into memory at full speed, rather than sending it through the somewhat slower NuBus. Two new custom application-specific ICs make this all possible: a Memory Decode Unit and a RAM-Based Video chip. The RBV maintains the display by supplying raster data from a first-in/first-out queue to the digital-to-analog converter that drives the monitor. When the FIFO is half empty, it requests more data from the MDU. The MDU uses a bus buffer to lock access to bank A of main memory and then performs a direct-memory-access (DMA) burst read of 32 bytes from the frame buffer into the RBV's FIFO.

There is a catch, though. While the MDU chip is grabbing video data, the CPU is locked out of memory bank A for 800 ns at a time. How often this occurs depends on the screen depth; since a deeper screen means that there is more data to read, bank A will be locked longer. This memory contention can reduce performance by 8 percent. With a cache card installed, of course, the performance penalty would be much less.

Fortunately, the Mac IIci's design holds a partial solution. In previous Mac II designs, memory had to be contiguous. This meant that higher-density SIMMs had to be installed in bank A first, and then in bank B. In the Mac IIci, the same MDU that assists the on-board

continued

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video also performs the physical address mapping for all the RAM, ROM, and I/O peripherals. The 68030's memory management unit then maps the physical addresses supplied by the MDU into a contiguous set of logical addresses. Simply put, the MDU/MMU address translations effectively "knit" noncontiguous physical memory into what appears to be contiguous memory to the Mac OS. Since the Mac IIci's memory is no longer required to be contiguous, it's possible to place the higher-density SIMMs in memory bank B without filling up bank A first. As a result, you can install a large complement of memory (up to 16 megabytes) that will never be hit by video subsystem lockouts.

How you use the Mac IIci can also sidestep the problem. When you use the Finder, important system globals used by applications are loaded into bank A, so there's a decrease in performance. If you use MultiFinder, it loads an application and these globals into bank B first.

When all the factors are considered, Apple claims that the on-board video still outruns NuBus video at screen depths of 1, 2, and 4 bits; with a cache board installed, it can even outrun NuBus at the 8-bit screen depth.

Another problem with on-board video is that the frame buffer's memory consumes system RAM. A 640- by 480-pixel display that's 1 bit deep requires a reasonable 64K bytes of RAM (actually only 38K bytes, but for performance reasons, RAM is allocated in 32K-byte blocks). When the same display is 8 bits deep, however, it requires 320K bytes of RAM. For a basic Mac IIci system with 1 megabyte of RAM, that's a huge percentage of available memory.

Exactly how much system memory the on-board video system uses depends on the amount of RAM available. With a 1-megabyte system, the Mac IIci defaults to the 1-bit-deep black-and-white display. You can override this by using the `Monitors` cdev, which is enhanced in System 6.0.4 so that you can adjust the size of the Mac IIci's frame buffer. With 2 megabytes or more, the Mac IIci defaults to the 8-bit-deep display. With a NuBus video card installed, of course, you eliminate the problems of memory lockout and frame buffer size entirely, but at the expense of using a NuBus slot.

New and Improved ROMs

The Mac IIci ROMs include significant changes from the Mac IIcx ROMs. To begin with, 32-Bit QuickDraw and patches to existing Mac II routines are now incorporated into the firmware (32-Bit QuickDraw lives as a RAM patch on the other Mac II–family computers). New additions to the ROM code include the driver for the on-board video, an enhanced Script Manager, a revised Slot Manager that better deals with NuBus master boards, and virtual memory support.

These ROMs were optimized for the 68030's architecture by arranging the code so that all the Mac Toolbox routines start at 16-byte boundaries. This arrangement matches the organization of the 68030's instruction cache and thus takes full advantage of the code cache's operation by ensuring that its 16-byte buffers remain filled. Since much of what a Macintosh does is accomplished by Toolbox routines, this provides an overall improvement in performance.

Using the Mac IIci is like being strapped into a rocket sled.

But perhaps the most important change to these ROMs is that the code is "32-bit clean" (i.e., it can fully use the 68030's 32-bit address space). Until now, the Mac OS has been hampered by the 24-bit addressing limitations built into QuickDraw and the Memory Manager—a legacy of the 68000's 24-bit address space. 32-Bit QuickDraw fixes the addressing problems with QuickDraw, and a new 32-bit Memory Manager, using a new master pointer structure, is embedded in the Mac IIci ROMs. However, until System 7.0 arrives, the older 24-bit Memory Manager, which is also embedded in ROM, will be used to provide compatibility with the existing software base.

What applications software might break on the Mac IIci? Those applications that rely on physical addresses (e.g., expecting Toolbox routines at specific addresses) will break. Also, any application that happened to work because of "memory wrapping" will now break. For example, an application might accidentally dereference an NIL window pointer. On other Macintoshes, this out-of-range memory reference truncates to a 24-bit address within physical memory, and unless an existing data structure gets corrupted, the window happens to work. However, the Mac IIci's MDU won't truncate the address but instead maps it to a physical 32-bit address. The 68030's MMU then attempts to access this nonsense address and signals a bus error.

Complex color applications should use the logical graphics device, `gDevice`, so that the Mac IIci can route the display to its on-board video subsystem. As usual, applications that follow the Apple software guidelines should work fine.

Observations

We had a chance to examine preliminary versions of both machines in late July and obtain some benchmark timings. Since we only had a few hours to examine a Mac Portable running a beta version of System 6.0.4, we can't comment on its expected battery life. But we determined that the Mac Portable is, without a doubt, a fully functional Mac. It ran popular software easily under MultiFinder, and the trackball was easy to use.

The bad news is that the Mac Portable's dimensions and weight place it in the "luggable" category, and you're certainly not going to rest it on your lap. Although you can carry it onto a plane, you won't be able to use it comfortably in-flight. Furthermore, it won't fit under some plane seats. On a Boeing 727, for example, the Portable in its carrying case would fit easily under the first-class and middle coach seats, tightly under coach window seats, and not at all under coach aisle seats. Clearly, though the Mac Portable is portable, its size and weight are its biggest disappointments.

The good news is that even without backlighting, the Mac Portable's active-matrix LCD is crisp and sharp, with excellent contrast. Although the tilt of the display is adjustable, we didn't bother with it because of the display's huge viewing angle.

The display is also exceptionally fast. The mouse pointer is always clearly visible on the screen: There's no blurring, no disappearing act. It's far and away the finest LCD screen we've ever seen, with or without backlighting, and it's better than most portable displays, period. Even if you don't plan to buy the computer, stop in to check out the display.

If you're used to a 68000-based Mac and have had the opportunity to try a 68030-based Mac, you may have compared the feeling to driving a sports car for the first time. Using the Mac IIci is like being strapped into a rocket sled: It's *fast*. For the first time, it is practical to

continued

Table 1: *On the BYTE Small-C benchmarks, the Mac Portable was roughly twice as fast as a Mac SE, and the Mac IIci was roughly 60 percent faster than a Mac IIcx. Disk I/O and floating-point performance were not measured. See text for details.*

PRELIMINARY BYTE BENCHMARK RESULTS

Text	Mac SE	Mac Portable	Mac IIcx	Mac IIci
Matrix	67.1	34.2	16.2	10.5
String move				
Byte-wide	374.5	174.9	82.7	51.8
Word-wide	186.7	87.4	42.1	26.6
Doubleword-wide	92.4	59.9	22.9	14.5
Sieve	170.2	84.1	31.4	19.8
Sort	154.2	76.3	29.7	19.4
Graphics				
Slow test	84.4	57.2	52.5	19.0
QuickDraw	1.1	0.7	0.3	0.2
Text				
TextEdit	15.1	9.9	4.6	2.8
DrawString	3.8	3.2	1.6	0.8

Notes
1. All times are in seconds.
2. Both systems ran the Finder.
3. The rest mode was disabled on the Mac Portable while running the benchmark tests.
4. The Mac IIci was set to 1-bit mode and had no cache board installed.

scroll through a document in 1-bit mode rather than having to page through it.

Performance and Pricing

We ran our BYTE Small-C benchmarks on the two computers to measure their performance. These results are preliminary, of course, but they do give a rough indication of the machines' capabilities. The benchmarks ran fine on both Macs, and the results are given in table 1.

As you might expect, the Portable easily outpaces the Mac SE, largely due to its higher processor clock rate. What you might not expect is that, under certain conditions, it's more than twice as fast as the Mac SE, as some of the memory tests (i.e., string and sort) and processing tests (i.e., Sieve and matrix) show. This is because the Portable, like the Mac SE/30, uses separate video RAM for the display's frame buffer. This eliminates the bus contention for memory between the processor and video circuits that occurs in the Mac Plus and Mac SE's design and so degrades their performance.

The Mac IIci is faster than the Mac IIcx. It's not an incremental step in performance, but a broad jump. As the tests on a stock Mac IIci (no cache board installed) show, the memory subsystem runs quite a bit faster: roughly 60 percent, the same as the increase in clock speed. We'll have to run application benchmarks to get the hard disk drive and heavy video usage into the act to see how well the Mac IIci performs overall, but the low-level results indicate that Apple's performance figures are probably accurate. The Mac IIci is a real processing powerhouse, and we haven't even considered the effects of the cache board.

Performance of the on-board video in 1-bit mode is very good: The Graphics Slow and Text DrawString tests ran at least twice as fast as on the IIcx. Even when the on-board video was set to the 8-bit mode, the times for the Slow test (21.9 seconds) and the QuickDraw test (0.23 seconds) were still better than those of a IIcx in 1-bit mode.

As we went to press, no firm prices had been set. However, you can expect the Macintosh Portable to cost in the range of $6500 to $7000—steep, but similar in price to 80386 portables such as the GRiDCase 1530, Toshiba T5100, and NEC PowerMate Portable SX, and only the GRiDCase 1530 uses a battery. If you're thinking about a Mac IIci, be prepared to pay a premium price: Estimates are $1500 to $2000 more than a similarly equipped Mac IIcx. Thus, a Mac IIci with 1 megabyte of RAM, a 40-megabyte hard disk drive, an Apple monochrome monitor, and a standard keyboard could cost about $7397. Mac IIcx owners will be able to upgrade to a Mac IIci with a logic board swap and a memory swap (remember that the IIci uses faster RAM). The prices and timetable for the upgrades had not been set.

Future Directions

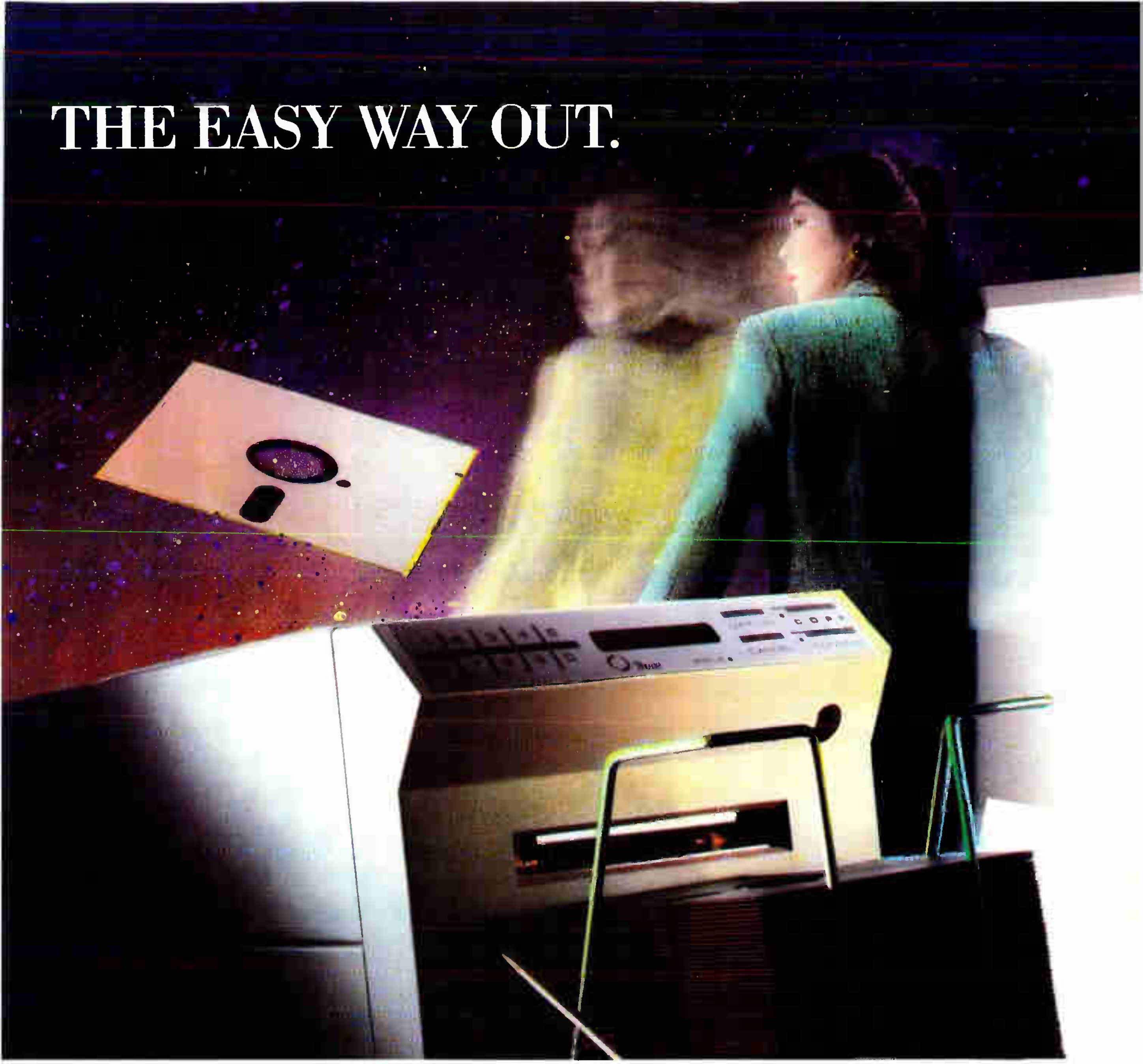
The Mac Portable is an impressive first try by Apple to enter the portable computer market. Now working professionals don't have to give up the Mac's unique processing capabilities while on the road. The Portable won't make more problems than it solves because its battery life promises to be good and its LCD is as easy to read as a piece of paper. If the designers compromised on anything, it was size and weight. But considering what's crammed into the Portable's case and the quality of its display, we commend their judgment.

A few months ago, an official for a major laptop maker commented that his company would never design another model with a nonbacklit screen and neither would his competitors. "Even they aren't that stupid," he told a press conference. A few months ago, that sounded like a reasonable prediction. But Apple has done nothing less than change the rules of the game. Five years ago, the graphical user interface of the Macintosh screen was the face of the future. Today, the Macintosh Portable's active-matrix LCD is the face of the future all over again.

The Mac IIci represents the first major jump in performance for a Macintosh computer since the Mac II was introduced over two years ago. Its computing power, on-board video, and small desktop footprint make it equal or superior to a PS/2 Model 70 system. The Mac IIci is clearly ready to tackle the large computing jobs coming in the 1990s because, on top of its processing power, it is prepared to work in a 32-bit address space, all the way down to its firmware.

The Mac IIci's design also tells us much about Apple's future plans. The design optimizations indicate that the Motorola 68030 processor will be the heart of the Macintosh for some time to come. However, with the computer's I/O decoupled from the rest of the system, it's going to be easier than ever before to design Macs using faster 68030s. But what's really a welcome trend is that cache slot; it indicates that Apple is finally going to try to reduce the CPU's burden by off-loading certain functions onto dedicated hardware. We hope that they're considering DMA channels and a graphics coprocessor in future Macs. ■

Tom Thompson is a BYTE senior technical editor at large. He can be reached on BIX as "tom_thompson." Frank Hayes is a BYTE news editor based in San Francisco. He can be reached on BIX as "frankhayes."



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VROOMM Goes the Spreadsheet

Borland's VROOMM technology gives the new Quattro spreadsheet plenty of capabilities in a relatively small amount of memory

VROOMM, which stands for Virtual Real-Time Object-Oriented Memory Manager, is Borland's alternative to OS/2 and Extended DOS. The new memory-expanding technique is similar to the overlays used in many large programs, but it is much more flexible. With it, Borland has been able to endow the just-announced Quattro version 2 with a large grab bag of features, making it a very strong competitor for Lotus 1-2-3.

We were impressed with the way VROOMM allowed the new program to fit into tight memory spaces. We also liked a number of Quattro's new features. But on some low-end systems, the overhead processing that VROOMM memory management requires carries a price in general performance.

What VROOMM Does

The whole point of VROOMM is to avoid the "out of memory" error messages that are increasingly common in these days of large TSR programs and memory-gobbling network drivers.

VROOMM is a virtual memory system based on small, variable-size program segments. Borland calls these segments "objects" since, like the objects in object-oriented programming systems, they can call each other. However, the VROOMM objects are modules of binary code rather than source code and do not appear to share some of the benefits of traditional objects, such as accessibility by outside programmers and inheritance.

Whatever name they're called, the VROOMM objects have a fine granularity—most are only 2K bytes to 4K bytes in size. This lets the program load into memory only those parts of the program that will most likely be used. It also means that, unlike with traditional overlays, objects will load from disk quickly.

All this is fine for Borland's programmers, since it gives them a lot of room to work with. Other programmers may benefit as well, since the company has stated that it will someday make VROOMM technology available as a programming tool. But the question now is, what can the new Quattro do?

Linking with 3-D

Probably the hottest issue in spreadsheets this year has been three-dimensionality, and Quattro does not ignore this trend. While it does not have true 3-D capability, in the style of the new Lotus 1-2-3 release 3.0 or the older BoeingCalc, it does have enhanced linking capabilities that allow you to simulate 3-D spreadsheets. Both approaches allow you to break up large, complex worksheets into several small, interrelated ones.

In 1-2-3 release 3.0, each cell in a spreadsheet has three variables: column (A to IV), row (1 to 8192), and page (A to IV). Quattro takes a different approach, choosing instead to stay with the 2-D spreadsheet, but enhancing the ways these spreadsheets interact with each other. In Quattro, you can display four spreadsheets (e.g., DEPT-A, DEPT-B, DEPT-C, and DIV-1), consolidating the results from three departmental spreadsheets. The consolidation spreadsheet, DIV-1, can easily access data from any of the departmental spreadsheets. You can also perform summations over several similarly named spreadsheets. For example, the `@SUM([DEPT-*]C7)` formula uses the DOS filename wild card * and calculates the sum of the contents of the C7 cells in every spreadsheet file whose name fits the `DEPT-*` specification (i.e., DEPT-A, DEPT-B, and so on).

Quattro can also access information from non-Quattro spreadsheet files on a network, or from database files that are being updated by other network users.

Annotating Graphs

Unfortunately, Quattro does not yet support true 3-D graphics; however, the graphics capabilities it does offer are truly striking. The program includes the usual assortment of pie charts, bar graphs, line graphs, and so on, plus new text-only charts. These graphs are greatly enhanced by high-quality text fonts.

In addition to a set of fairly standard fonts (e.g., roman, sans serif, and Old English), Quattro includes a small set of Bitstream fonts. These fonts produce very high-quality text on a laser printer, as you might expect, but they can also do a surprisingly good job on a low-end dot-matrix printer.

Whenever Quattro needs a Bitstream font in a particular size or style (such as bold or italic), it generates the appropriate font file. This can happen whenever you view, annotate, or print a graph, or when you view or print a spreadsheet. Generating each file can take a lot of time, especially on slower machines, but once that particular font file is generated, you do not need to generate it again. You can save some time by generating most font files at once when you install the program. However, all these font files take up a lot of disk space and dominate your Quattro directory.

Another interesting part of Quattro is its annotation facility, which allows you to modify graphs in a WYSIWYG fashion. With this feature, it is easy to select text and move it around the screen, or to

continued

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add a small text box and an arrow pointing to a particular feature of a graph.

Quattro's graphics capabilities also include two other features not often found in spreadsheet programs: the ability to include graphs inside spreadsheets, and the ability to arrange graphs into a slide show–style presentation.

"Publishing" Spreadsheets

One of the strong points of the Windows- and Macintosh-oriented spreadsheets, such as Excel, is their ability to use multiple fonts, both on the screen and in printed documents. The problem with this approach is that drawing the various fonts on the screen can take a lot of time.

Borland has implemented a compromise approach for Quattro. You can have up to eight different fonts in the printed version of your spreadsheet, but, to save time, the on-screen version of your spreadsheet will show only one standard font. As you can imagine, it can get a little confusing trying to remember which cells in a spreadsheet are in which font. You can preview the spreadsheet to see what it will look like when printed, but this takes some time.

Quattro also includes other desktop publishing–like features, such as boxes, grids, and shading. And, unlike the case with the text fonts, Quattro does give you some indication on the screen as to what the lines will look like. Unfortunately, the lines on the screen take up a whole row or column, thus reducing the amount of the spreadsheet that you can display on your screen.

Recalculations Faster than 1-2-3

In tests of brute-strength recalculation, our early version of the program invariably beat out all the current versions of 1-2-3 (releases 2.01, 2.2, and 3.0). This speed advantage may be due in part to what Borland calls Intelligent Minimal Recalculation, where the program somehow decides whether it is faster to do a minimal recalculation or a full recalculation (when almost all the cells are involved, as in most benchmark tests). Quattro also features background recalculation, which can make the program seem even faster.

The early version of Quattro was also fast at scrolling and inserting rows. One area, however, where Quattro seems to be slower than 1-2-3 is with operations regarding disk access, such as loading the program or loading spreadsheets.

I should also add that benchmarking, while never easy, is particularly hard with Quattro. The problem has to do with VROOMM and the way Quattro—or the part of it that resides in memory—keeps changing from operation to operation. For example, we found that in some cases a recalculation got faster on successive iterations or slowed down, depending on which part of the spreadsheet was displayed.

Another weakness of VROOMM is apparent even to a casual user. Sometimes, every keystroke that you enter results in a disk swap. This is related to the small size of the VROOMM objects: Although they will load quickly, they must also be loaded more often. This is especially noticeable on low-end systems or when you are using very large spreadsheets. After loading a 335K-byte spreadsheet, the program told us we still had 40K bytes of memory left, but it became extremely slow. Whenever we hit a cursor key, a considerable amount of disk swapping took place. Borland claims, however, that this will be speeded up by the time the product ships.

A 1-2-3/Windows Hybrid

In general, the new Quattro, like the original version, is pretty much a cross between 1-2-3 and Excel. It provides both good 1-2-3 compatibility and superior printing and graph-making capabilities. And it provides a rash of other features, such as Undo, a transcript of user actions (useful for macros or returning a spreadsheet to a previous condition), the ability to edit menus, good mouse support, and the ability to read and write a large number of file formats without translation. The product's list price is $495, twice that of the previous version.

Our only serious complaint with Quattro is that there should be some way for users to signify different fonts on the screen. Also, VROOMM's object-swapping mechanism is a little slow, but that will probably be fixed by the time the product ships. Otherwise, Quattro looks like a very useful product, especially for users who want the advantages of Excel (and then some) but do not want to sacrifice compatibility with 1-2-3. ■

Rich Malloy is an associate managing editor for BYTE. He can be reached on BIX as "rmalloy."

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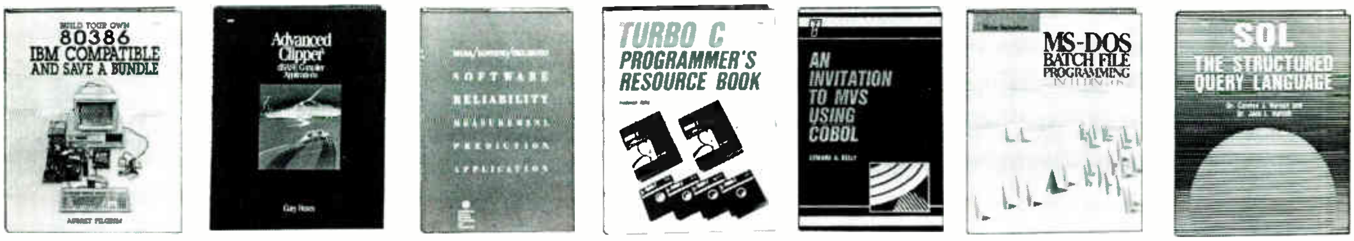

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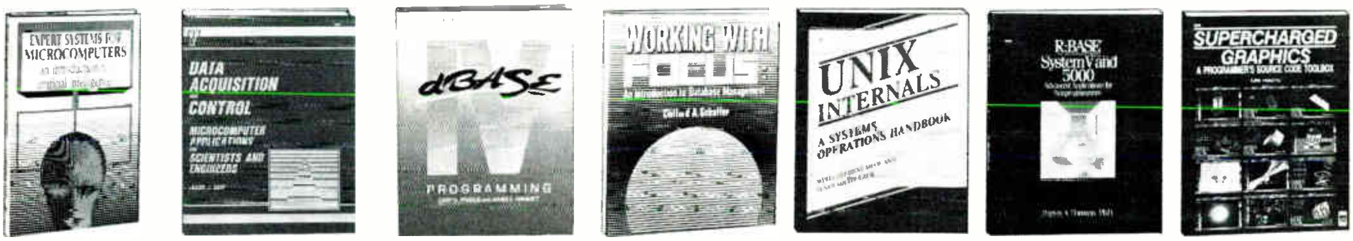

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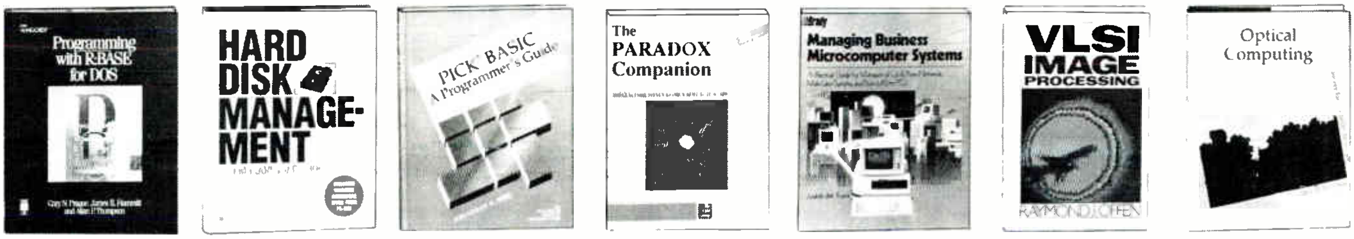

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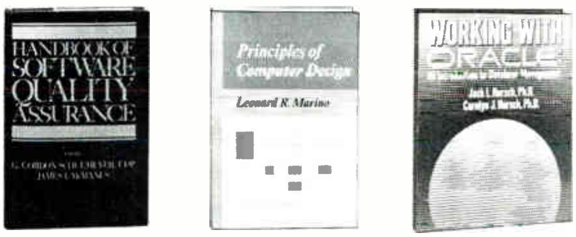

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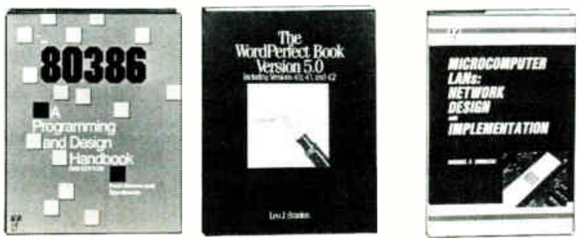

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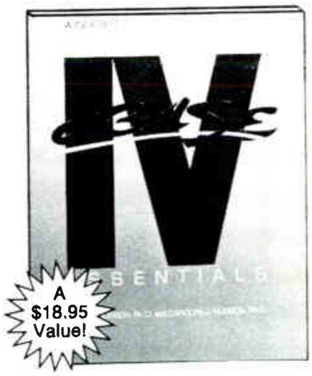

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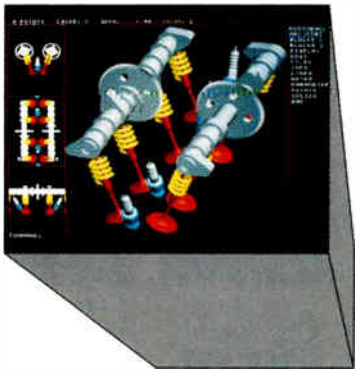

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Still don't believe us? The goblet pictured below required only 16 keystrokes and 3 commands to create! The top, front, side, and isometric views were created simultaneously... in less than one minute!

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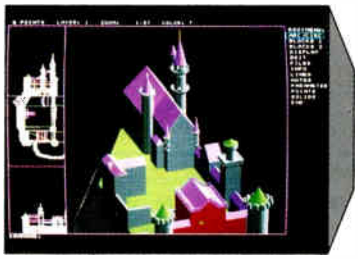
The first question asked by many people is, "Why is DesignCAD 3-D priced so low?" The answer? After developing DesignCAD 3-D version 2.0, we were unable to decide how the product should be priced. We consulted experts. We used the finest spreadsheets on the market. We took employee polls. Finally, in the great American Tradition, we said, *"Aw... What the Heck! Let's see the other guys beat this price!"* DesignCAD 3-D version 2.0 sells for $399.

DesignCAD 3-D only $399!



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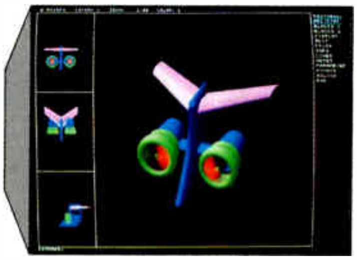

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HENRY LEVET, Levet & Daigle Architects · New Orleans, LA
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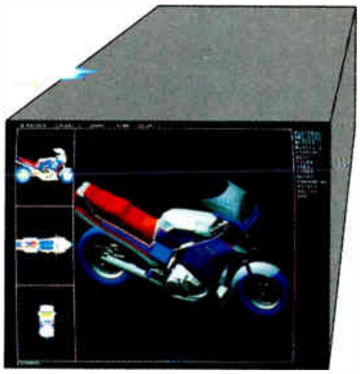
"Recently I worked with a firm that builds decks. They purchased your product on my recommendation. I sat down with them and in two hours they were very proficient in DesignCAD. Now they are more effective; and we can communicate... it's wonderful to be able to do a block repeat 42 times and there are 42 2x4's to make the deck!"

J. TURNER, Architect, TAO Ltd. · The Woodlands, Texas

"Allows scientists and engineers to expend minimum time learning and using CAD software so that their time can be expended on the project at hand. It also allows scientists and engineers to quickly present to management all views of a subject (3-D)."

DR. STEVENS, NASA Space Scientist/Engineer



HOW DO I GET ONE?

DesignCAD 3-D version 2.0 is available from most retail computer stores, or you may order directly from us. DesignCAD 3-D is available in a number of foreign languages from distributors throughout the world. All you need to run DesignCAD 3-D is an IBM PC Compatible and 640K RAM. DesignCAD 3-D supports most graphics cards, printers, plotters and digitizers. Free information and a demo diskette are available by contacting us at:

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DISASTERS AND DIVERSIONS

The agony of a drenched disk and the thrill of new CD-ROMs

I have just spent half an hour using Krazy Glue and epoxy to mend an Austrian ceramic *ButterKasse* we bought during our trip to Graz three years ago; it arrived broken in shipment. Given just how far behind I am—*Wrath of God* is going to be good, but writing it has been blooming slow work—you'd think something that has waited three years for repairs might be allowed to wait a little longer, but read on. A story goes with it.

It all started when I got an Amiga game called Populous, written by Bullfrog Games and published by Electronic Arts (EA). Populous is one of a recent flock of new programs for the Amiga. Most are games, but I'm told by people I trust that there's a flood of new general-purpose and business products for the Amiga just around the corner. By contrast, Atari seems to have fallen into the doldrums and is pinning its hopes on becoming another PClone maker.

I've always had a soft spot for Commodore, a company that's trying to do new and innovative things rather than follow the crowd, and the Amiga remains one of the most interesting machines around.

Anyway, shortly after I got to looking at the box blurbs for Populous, it became clear that this is no ordinary game: it appears to be an electronic implementation of the Manichaean heresy. The blurbs include: "Cruel ice, lush grassland, parched desert. With 500 worlds, a deity's work is never done" and "The all-powerful can perform miracles in their sleep. But omnipotence isn't what it used to be. These days, it takes an awesome natural disaster to dominate a world." This is clearly not your run-of-the-mill computer game.

However, it takes determination to play this game if you have an Amiga 2500. My first attempt was a failure. That is: I treated the thing much as I would a game for the Macintosh. I booted up the system, inserted the Populous disk, clicked on its icon to open it, clicked on the Populous icon—and found myself stuck in the demonstration mode. It wouldn't actually play the game.

This is because EA has an arcane copy-protection scheme. It requires you to boot up your machine, catch it before it loads the rest of the operating system, and insert the EA game disk. AmigaDOS comes in two parts: the DOS itself, and a disk of programs called the Workbench that you must have to do anything other than play games.

Many EA games require you to substitute the game for the Workbench, which is easy enough if you boot up with floppy disks but requires tricky timing if you have a hard disk. Doing it the EA way deprives you of the Amiga's main advantage, true multitasking; the Workbench runs at least as well as Macintosh's MultiFinder.

Booting up with the Populous disk already inserted in the floppy disk drive didn't work either. It got me to the introductory part of the game, including instructions and the tutorial, but when I attempted to actually play, the machine went galley-west. Now what?

A quick call for help on BIX got me the following advice: the Amiga 2500 has both 68000 and 68020 chips on-board. Left to itself, the machine uses the 68020, but if you hold down both mouse buttons when you power up, you're given a choice of booting with either chip (or with Unix, although that's not implemented yet). To play Populous, you must tell the machine to boot with the 68000. It seems there exist in the 68000 instruction set a couple of commands that have inconsistent undocumented features. When Motorola brought out the 68020, there were fixes. Alas, some Amiga programmers like the 68000's incompatible instructions.

Anyway, booting with the 68000 chip did the trick: Populous worked fine.

Fascinations

It turns out that the silly game is fascinating; at least it was for me. It's fairly easy to learn. It's strategy-oriented but works in real time. You can pause the game, but if you don't, you sure can't just sit there and watch, lest Satan kill off all your followers. Not every second counts, but certainly every minute does.

The graphics are neat. The user interface is odd but learnable. Despite appearances, this isn't a game review, so I won't go into details; suffice it to say that I started playing this strange game at midnight and found myself still sitting there at 7:00 a.m. listening to the birds. Worse: that happened *twice*. Which still doesn't explain why I was mending a ceramic *ButterKasse*, but read on.

Meanwhile, it's summer-vacation time here at Chaos Manor, and our youngest son, Richard, is taking the summer off from college. One way he's been amusing himself is with Accolade's Fast Break 3-on-3 basketball game on the Amiga. He plays in the mornings before I get up—on this particular morning, after I came to my senses and turned off the Amiga.

An hour ago I came upstairs to finish this column. I'd had it about half done before I started Populous last night—I'm not a *complete* idiot—so it looked to be a short job. First, though, a quick look at Populous, "to get a couple of details to write about," said I to myself. When I booted up, the Amiga pronounced my disk—the uncopyable, irreplaceable Populous disk—unreadable.

Close examination showed just why. While I was asleep, Richard had managed to upset a glass of orange soda on

continued

the Populous disk, and it was now all wet and sticky.

Futility

Years ago I read about a library whose 8-inch CP/M floppy disks were all soaked in dousing a fire. Since there was nothing else to try, the librarians dried out the disks—and lo, they worked. Maybe, thought I, the same could be done with the 3½-inch Populous disks. What the heck, it was worth a try.

There were four disks soaked in orange soda. I washed them all out and set them in front of a fan to dry. Then, being impatient, I experimented with one of them: wash it out, shake it to get as much water out as possible, and try to dry it with a hair dryer.

That didn't work.

Neither did letting the disks dry naturally at low temperature in front of a fan. I put one disk on top of the vent from the Zenith FTM monitor, where the temperature is about 109°F. That didn't work either.

In fact, nothing I tried worked. Unlike 8-inch and 5¼-inch floppy disks, if a 3½-inch disk gets wet, it's probably just plain dead.

Certainly my Populous disks were dead. Nothing for it but to get another set. To do that, I'd have to telephone the company.

No phone number on the Populous box. Maybe on the game manual? But my desk was all set up for doing the column, meaning that it was covered to a depth of 9 inches in paper and boxes and manuals, so it took 10 minutes of increasingly frustrating activity until I found the Populous manual. Of course, it had no phone number in it, and while I was looking for that manual, I managed to kick over the large glass of water Richard had left on the floor by the Amiga....

While I cleaned that up, Mrs. Pournelle got the phone number from Pacific Bell information. I called. Two rings, and it was answered by a computer that began an interminable spiel, offering me the opportunity to get various people I didn't want to talk to if only I'd punch in various numbers; eventually I punched "0" and got a human. By now I was speaking in a preternaturally calm voice: "Please let me speak to the product manager for the game called Populous."

There were several mysterious clicks and clanks and sounds from the telephone. Several rings. More clicks. Finally a recording told me that someone, I forget just who, wasn't available, and would I care to leave a message? Very slowly and calmly I hung up and dialed the number again. I got the machine, but punching "0" got a human—so far as I knew, the only human EA employed. "The product manager for Populous isn't answering," I said carefully. "May I have the director of public relations or press relations?"

This time I got a very pleasant young lady who much sympathized with my problem and promised to mail me a new disk. Now it's time to have a few words with my son. I figured that before I did that I really ought to calm myself: I should do something requiring a maximum of care and patience and a minimum of brain—and that, preferably, has nothing to do with either computers or people; at which point I spotted the broken *ButterKasse*....

I'm sure there's a moral to this story, but I'm not certain what it is.

First, who's the villain? The proximate cause is Richard for spilling the drink, but my leaving it on that table is at least contributory negligence. In any case, the incident wouldn't have been worth mentioning if it hadn't involved an irreplaceable disk.

Next, there's EA with their arcane copy-protection scheme, which not only makes the disk irreplaceable, but also makes the game frustratingly hard to boot up and play. Behind them are the petty thieves—they like to call themselves "pirates," but they don't deserve such a glamorous term—who copy and distribute copyrighted software and make EA believe that copy protection is necessary.

For reasons I have never quite understood, in the Amiga and Atari worlds it's very common for stolen copies of new games to be available on BBSes and at swap meets as soon as they appear on the market—indeed, sometimes before they're officially released.

The rest of the computer world is abandoning copy protection. In the IBM PC world, I think there are no copy-protected games at all; instead, the companies rely on "security checks," in which you're required to type in a word from the manual. This doesn't prevent illegal copying of the games—manuals can be photocopied—but it does slow things down, and it's pretty hard to distribute a printed manual on a BBS.

There's still some copy protection in the Mac world. Less every year, though, and what's left is the "key disk" variety that lets you play a game off a hard disk and checks only to see that you've got the original distribution floppy disk.

In the Amiga and Atari worlds, copy protection is the rule rather than the exception.

I don't know why this is. I do note that there are fewer Macs than PCs, and fewer Ataris and Amigas than Macs. The elaborate manuals customary for PC games may be too expensive an investment for the smaller markets. Finally, copy protection is much harder in the PC and Mac systems than in Atari and Amiga systems. Really wicked schemes like the unlamented ProLock are harder to implement. Besides, anyone can buy disk copying programs like Copy II PC and Copy II for the Macintosh if they get unhappy enough. If there's something similar available for the Amiga, I don't know about it.

Whatever the reason, I sure wish companies like EA would rethink their position. The house rule at Chaos Manor is that I won't review copy-protected business software. I will look at copy-protected games. That doesn't mean I like having to do it.

Words!

The latest item at Chaos Manor is the *Oxford English Dictionary* (*OED*) on CD-ROM. I've had it for about a week now, and it's just wonderful. Every word in the English language—well, every word used up to 1928, anyway—with every meaning, its history, who used it first in print, and who's typically been using it since. Just this year, they brought out a new and revised edition of the *OED* that brings it up to the 1980s.

I first got the *OED* in the two-volume set (complete with magnifying glass in a small drawer of the slipcase) as a bonus for joining the Book of the Month Club. (Karen Anderson dubbed that the "transistorized version," which tells how long ago *that* was.) I use it at least weekly, although it isn't very convenient: the books are enormous and hard to set down, and the magnifying glass is a must. Thus, I was quite excited at the prospect of getting the *OED* on a CD-ROM.

The OED CD-ROM is the original edition—alas, without a four-volume *Supplement*. A new CD-ROM of the second edition is in preparation.

The manual states that "The *OED* on CD cannot be a substitute for the book itself, since reading its very long entries on screen (some are as long as 60,000 words) would be tiring and impractical...." I've got news for them: compared to reading those lengthy entries in the tiny print of the transistorized version I've got, reading them on the screen is flipping bliss.

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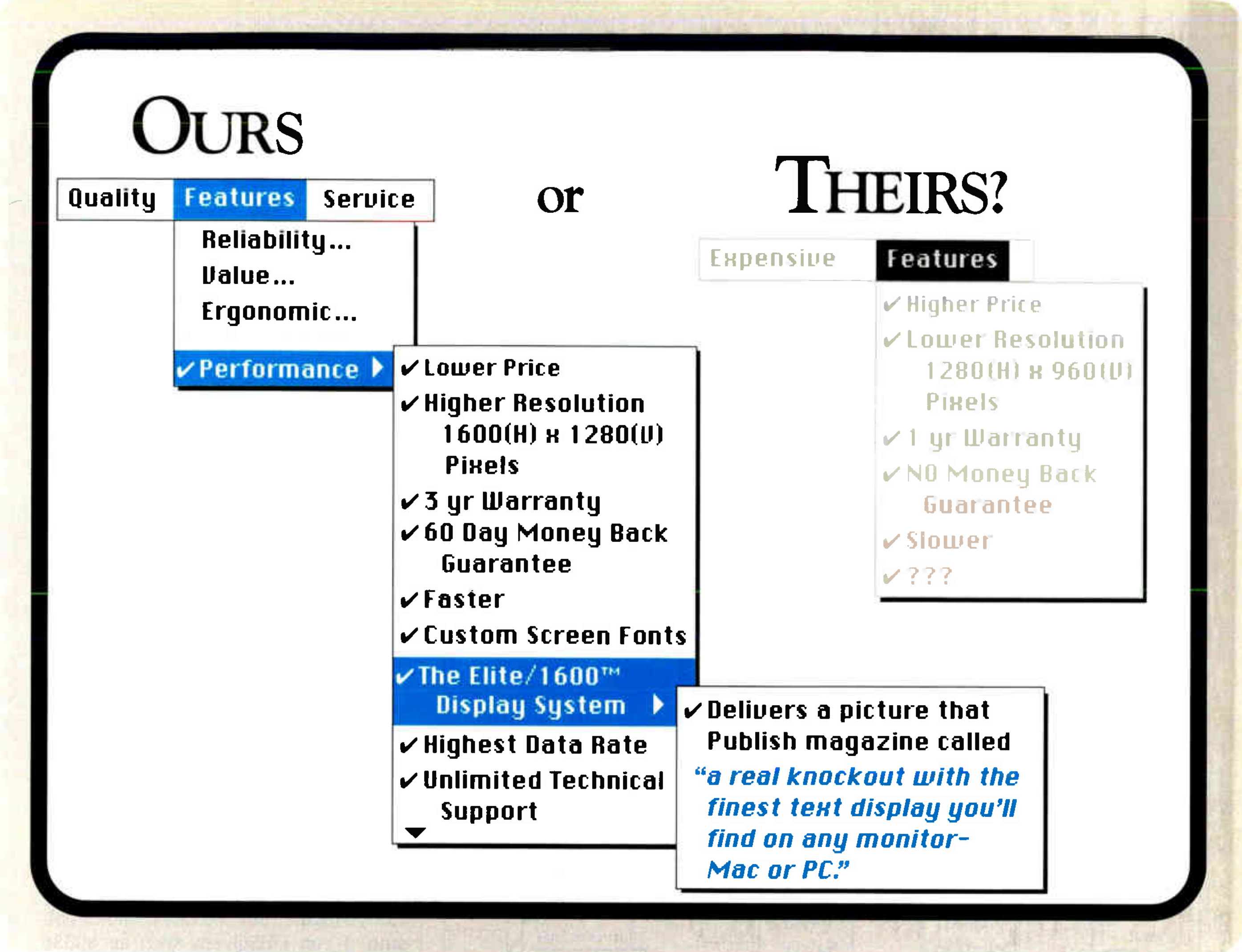

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The OED CD-ROM is extremely well indexed and has good retrieval software. The user interface is really odd. To look up a word, you set a variable called "the lemma" to equal the word. Naturally, on learning that, the first thing I did was "set lemma=lemma." For my pains, I got four screens of definitions and origins. The first definition is the expected one from mathematics. The second definition is: "The argument or subject of a literary composition, prefixed as a heading or a title," which, when you think of it, sort of fits, since once you've set the lemma, the OED CD-ROM lets you look things up in a variety of ways.

You can see every instance of its use; you can see which writers used it in ways the *OED* editors thought worth recording. You can look up its etymology. Doing that with the word *lemma* took me to the word *dilemma*, which is a term originating in rhetoric and formal debate; also to *argument*, which originally didn't mean "dispute" but referred to the points you made in a debate; and so forth, for 10 minutes before I got back to work. The OED CD-ROM is a wonderful time trap.

Some of the other features aren't easily learned, either. I just looked up the word *phoenix* and was told it couldn't be found, but to try the spelling index. Eventually I figured that one out: tell it the lemma is ph*, and it wants at least three letters. Tell it it's pho*, and it finds nothing. Tell it phe*, and by gollies it finds *phenix*, which is listed as "obsolete spelling of ph<oe>nix," and finally *ph<oe>nix* itself. It won't search on ph<oe>*. This isn't an optimum way of handling diphthongs. I can live with it, but I sure wish they'd fix that in the next edition.

You can get the OED CD-ROM direct from Oxford University Press. Mine was arranged courtesy of the (private dealer despite the name) Bureau of Electronic Publishing (P.O. Box 779, Upper Montclair, NJ 07043, (201) 857-4300), which puts out a catalog of interesting CD-ROM products, including both disks and drives.

I had no trouble at all getting the OED CD-ROM to run inside its own DESQview window (but see last month's column; I run DESQview with an 80386 and QEMM-386 to get *big* windows). Alas, unlike Microsoft Bookshelf, the OED software isn't memory-resident; you can't run anything else like a word processor with it, and for that matter, it eats up so much memory that I wasn't even able to get SideKick up—I'd hoped to use SideKick to cut and paste. However, the DESQview Notebook utility does work properly, letting you cut stuff out of the OED CD-ROM screen and paste it into other windows.

I can think of tons of improvements they could make to the user interface, but so what? What's here now is wonderful. I could rave on for the rest of the column. For anyone in love with words, the *OED* on CD-ROM isn't just recommended, it's a necessity, and more than enough reason to go buy a CD-ROM drive. (Indeed, enough CD-ROMs are out there now that I wish I could have several drives on-line at once: OED, Microsoft Bookshelf, World Factbook. . . .)

Romanji

I was never any use at foreign languages. Somehow I got through high school Latin, which greatly improved my English. The University of Washington Ph.D. program required knowledge of

continued

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Logitech Mouse $139
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Incidentally, I used the DESQview mark-and-transfer routine to move the definitions from the OED window to this one. Works like a charm.

Try the WF-224 again. The sixth word this time was *abscission*. Well, all right, I know what that means, but I can't say I was *sure*. Try again. It took 18 tries to come up with *perfecto*, which turns out to be a thick tapered cigar, and no, I didn't know that. I thought they'd included a word of foreign origin.

The WF-224 also checks spelling. If you punch in *Pournelle*, it says that's spelled right. But if you give it *Pournell*, it corrects it to *perennial*; however, if you hit the right-arrow button, it finds something else and will keep trying until, by gollies, it gets *Pournelle* on about the fourth try! It accepts *perenial* and gives the right answer, but if you give it *mispeled*, it finds *misapplied* as the first choice; keep hitting the right arrow, though, and it gets it right.

It's a fun gadget. I'll lend it to one of my college sons and see what happens.

Of Mice and Bugs

Logitech has new mouse software. They no longer bundle the Point editor with their mice, although I gather you can get it if you buy their desktop publishing package. Now they include a thing called Pop-Up DOS, which is a DOS shell. Pop-Up DOS enthusiasts swear it's easier to use and just plain better than Norton Commander. Maybe. I'm quite certain that had I learned Pop-Up DOS before I learned the Commander, I'd never have been tempted to switch; now the burden's the other way, and so far I'm still using the Commander, but we'll see as time goes on. One thing: Pop-Up DOS comes with a good tutorial and reference book, although I do wish the index and table of contents were a little more thorough.

Obviously, Pop-Up DOS works well with a Logitech mouse. You get the help file by pressing the center mouse button, for example. They've kept the pattern from Niklaus Wirth's Lilith operating system, in which the center button produces a menu, the left button executes commands, and the right button makes the menu go away and generally acts as the Escape key; but since that can drop you right out of the program, Pop-Up DOS requires that you double-click on the right button or physically press the Escape key.

Pop-Up DOS does a number of things similar to the Norton Commander. It shows a full tree of your hard disk directory structure. There's a neat little card

continued

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MKS

More Power to You

file built in; alas, there's no provision for sorting those silly cards. I'm seriously thinking of writing a small Turbo Pascal program that will do it. You can launch programs from within Pop-Up DOS, but in addition you can link programs. You can define all .GV files as GrandView applications, so if you double-click on a .GV file, it launches GrandView with that file in it.

Other Pop-Up DOS features include a calendar, a hexadecimal/decimal calculator, and a small editor that is more than good enough to edit stuff like AUTOEXEC.BAT, CONFIG.SYS, and generally whatever else you want. Unlike the SideKick editor, it doesn't do word wrap. On the other hand, it works nicely with mice (as you'd expect). On the gripping hand, Pop-Up DOS has no view or examine function that lets you read files; to get the equivalent of the DOS TYPE command, you have to either exit Pop-Up DOS or click on the file bringing it into the Pop-Up DOS editor—either of which is inconvenient compared to Norton Commander's F3-view command.

In other words, Pop-Up DOS is a reasonable competitor to Norton Commander and other DOS shells, and since you get it free with the Logitech Mouse, it's certainly worth trying, especially if you haven't got used to something else.

That's the one hand. On the other hand, the new Logitech Mouse has an odd shape: instead of the modified wedge that Logitech has made famous, the new version looks like a slice of a cylinder. Some people like it. I don't; I have trouble distinguishing the buttons.

On the gripping hand, by the time you read this, Logitech will have brought out a new trackball. I've had almost no time to play with it, but from what little experience I've had, I think it may well replace the mouse as the proper pointing device. I know there have been trackballs before, but most have been clumsily designed. The Logitech trackball is small; it's set so that you manipulate the ball with your thumb, leaving the fingers to rest on the buttons in a natural manner. This is definitely the right way to go. More next month.

Finally, while I'm discussing Logitech, I want to again praise MultiScope, their new OS/2 Presentation Manager debugger. While MultiScope naturally works with Logitech Modula-OS/2, it's also the best debugger I know of for IBM C/2, Pascal Compiler/2, and Macro Assembler/2; and for Microsoft C, Pascal, and Macro Assembler. It works in both run-time and postmortem modes and with both OS/2 Text and PM.

If you're programming for OS/2 in *any* language, you need MultiScope. Highly recommended.

Failure

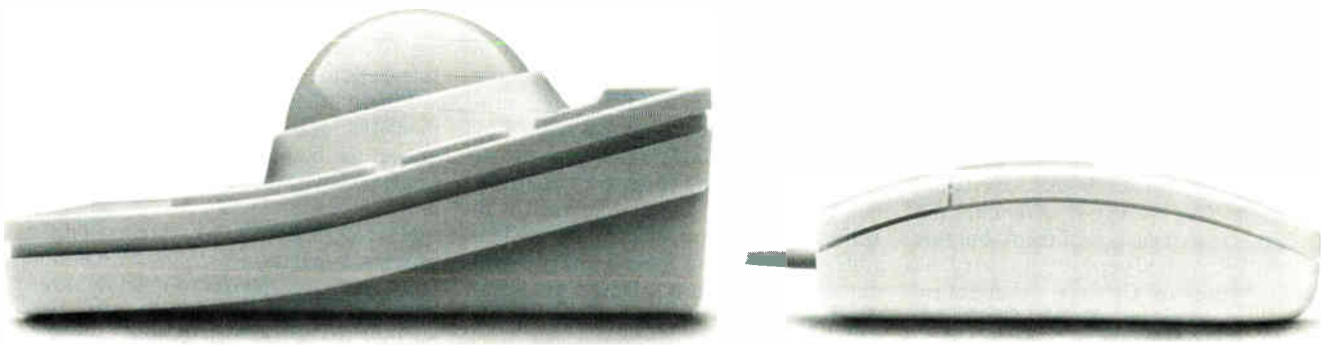
I keep hearing wonders about Windows, and Windows/386 in particular. More, I have Amí, a Windows text editor and desktop composition program that looks awfully good in demonstrations. This looked like a good program to try on the new Northgate 386 with the Video Seven VGA card and Princeton monitor.

There's only one problem. It takes 40 minutes to install Windows/386. When I finished this tedious process, the program reported that everything was all right, and I only needed to reboot and type WIN386. I did that, the screen flickered, and I was back at DOS again. No error message. Nothing. Just click, clack, and no effect.

Clearly, there are some odd bugs in

continued

How an upside down idea made the mouse obsolete.



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Windows/386; perhaps I'll learn, but for the moment I think I'll stick to DOS and DESQview. It's sure less frustrating. I have installed Windows/286, but just now I'm sufficiently disgusted with Windows that it wouldn't be fair to Amí to try it. I'll report on it another time. Meanwhile, I sure wish Microsoft would get its installation act together. It could at least give an error message.

Grolier

I keep my radio on the local university's good music station, and tonight they're doing a docudrama about the French Revolution, with Captain James Tiberius Kirk (aka William Shatner) as Robespierre yet. One event portrayed was the assassination of Marat by Charlotte Corday. I got to wondering what happened to her after she stabbed Marat (who certainly had it coming).

I've got plenty of books, including Carlyle's *The French Revolution*, and Corday's story is in one of them, but this seemed like a good opportunity to try the new version of Grolier's Academic American Encyclopedia on CD-ROM. You may recall that this was just about the first CD-ROM of any size to be published, and Gary Kildall's Knowledge Corp. developed the early indexing and data-retrieval software. The user interface was, to be kind, not optimum. Since then, there have been several revisions.

Installation of the new version 2 is straightforward: the program comes with a floppy disk as well as the CD-ROM. Put the floppy disk in drive A, log on, and type Install. It takes care of the situation from there.

I'm pleased to say that the new Grolier software is considerably improved over the first version. It's now quite intuitive. There are also multiple (up to 10) windows and hypertext links from one article to another, which is neat.

Looking up Corday yielded six references in four articles. The primary one told me that she'd been guillotined, which I suppose is no surprise, since almost everyone you ever heard of who lived in France around 1789 seems to have been shortened. I then got myself trapped playing around with linkages and ended up reading a lot more about European history than I'd intended; the hypertext-link feature really does work, making it simple to trace down ideas.

Grolier's Academic American Encyclopedia isn't the world's best encyclopedia, but it's certainly not the worst. It does get rather cursory in places, and details of history aren't its strongest point; but then encyclopedias are supposed to be a starting point for learning, not the entire accumulated knowledge of the human race. You can learn a lot browsing through it with hypertext links.

I do wish they'd use the new Grolier retrieval software on an even more complete encyclopedia, but until they do I'm glad to have this one. Recommended.

Languages Yet Again

I've been considering just what you can do with Turbo Pascal. Modern programmers would have you believe that Pascal and Modula-2 are dead, and that C is the only viable language. For my money, that just isn't so.

Indeed, I'd go the other way: every time I hear of a big software project in trouble, I find it was written in C. More to the point, it was written by one programmer but needs to be maintained by another. Under those circumstances, C becomes something close to a write-only language, particularly if combined with Unix. The code is perfectly comprehensible to the person who wrote it—provided said person is a full-time programmer—but it becomes unfathomable for someone coming in from outside.

Pascal, on the other hand, and in particular Turbo Pascal, may not completely live up to Niklaus Wirth's goal of a self-documenting language, but it's sure closer than C. True, Pascal doesn't always produce code that's as compact as C code; but it's generally good enough, and me, I'd rather have fat, understandable code than a program that's compact, efficient, and incomprehensible.

For that matter, BASIC most certainly isn't dead. If you take Microsoft QuickBASIC and add toolkits like those published by Crescent Software, Hammerly Computer Services, and MicroHelp, you can do anything you like, including TSR programs. True, compiled BASIC makes for fat code, but most of the tools I mentioned are in assembly language and will thus be smaller and run faster than the same stuff in C. If you make a program that's largely links between assembly language routines, the result can be quite impressive—and still be readable. I'm in the process of going through Mrs. Pournelle's Reading Program and replacing my own code with routines from these toolkits, and the result is gratifying.

I've been saying this for years, and I still believe it: the real computer revolution comes about when people stop having to worry about *how* to make the computer do something and concentrate on *what* they want it to do. Moves—such as Windows and OS/2—that take us toward the use of C and other arcane languages are steps in the wrong direction.

OS/2 got more accessible when Logitech put out Modula-OS/2; it will get even more so when we have QuickBASIC and Turbo Pascal for OS/2.

Winding Down

There's still an enormous pile on my desk. There's Expert 87 from Magic 7 Software, which looks fair to be the PC-DOS "expert system generator" for the rest of us. I liked the original version, and it has been revised to be even better. A bit complex, but that kind of program always is. Recommended.

There's WordStar 5.5, which is so much improved I may change over; if they'd had this four years ago, WordStar International would own the world.

Finally, there's ProIcon, a Mac implementation of the Icon programming language (the book *The Icon Programming Language* by Ralph and Madge Griswold is available from Prentice-Hall). This is a high-level, SNOBOL-like, string and list processing language (see "SNOBOL and Icon" by Ezra Shapiro in the July 1985 BYTE) available on Unix systems, including the VAX, the Amiga, and the Atari ST. Programs in Icon look a bit like a cross between Pascal and C. It is not as strongly typed as Pascal, but more so than C. More another time.

The pseudobook of the month is *The Man-Kzin Wars II* series created by Larry Niven; the story of interest is "The Children's Hour," a novella by Pournelle and S. M. Stirling (Baen Books, 1989). The real book of the month is *The Bloody Crossroads: Where Literature and Politics Meet* by Norman Podhoretz (Simon and Schuster, 1986, $16.95). I particularly liked his essays on George Orwell and Albert Camus.

The game of the month is Accolade's Fast Break 3-on-3. Richard says it's very hard to learn, but once you've got the hang of it, it's both fun and instructive. It must be fascinating; he's still coming up here to play it on the Amiga. We're both a lot more careful about orange soda. ■

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."

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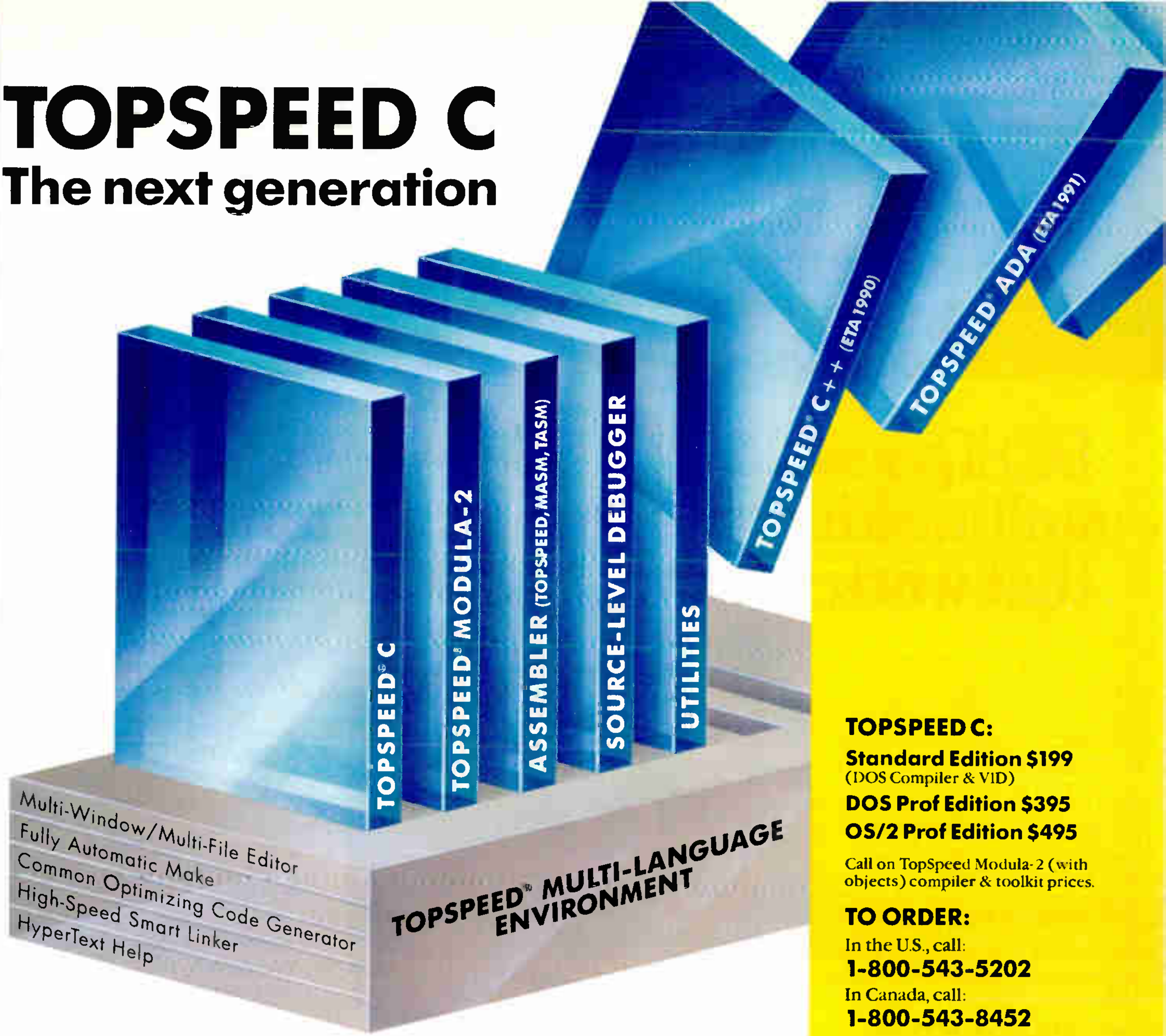

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API C Library

Here are C language interfaces for the entire set of API functions. It supports the Lattice™ C, Metaware™ C, Microsoft® C, and Turbo C compilers for all memory models. Included with the C Library package is the API Reference Manual and source code for the library.

API Pascal Library NEW!

The Pascal library provides interfaces for the entire set of API functions. It supports Turbo Pascal V4.0 and V5.0 compilers. Included are the API Reference Manual, source code for the library, and example programs.

API Debugger

The DESQview API Debugger is an interactive tool enabling the API programmer to trace and single step through API calls from several concurrently running DESQview-specific programs. Trace information is reported symbolically along with the program counter, registers, and stack at the time of the call. Trace conditions can be specified so that only calls of interest are reported.

API Panel Designer

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The Panel Designer automatically generates all the DESQview API data streams necessary to display and take input from your panel. These data streams may be grouped into panel libraries and stored on disk or as part of your program.

More Tools are Coming

Quarterdeck is committed to adding tools as needed by our users. To that end we have been working with Ashton Tate and Buzzwords International on dBASE III and dBASEIV translators. And in the works, we have BASIC and DOS Extender libraries.

Quarterdeck

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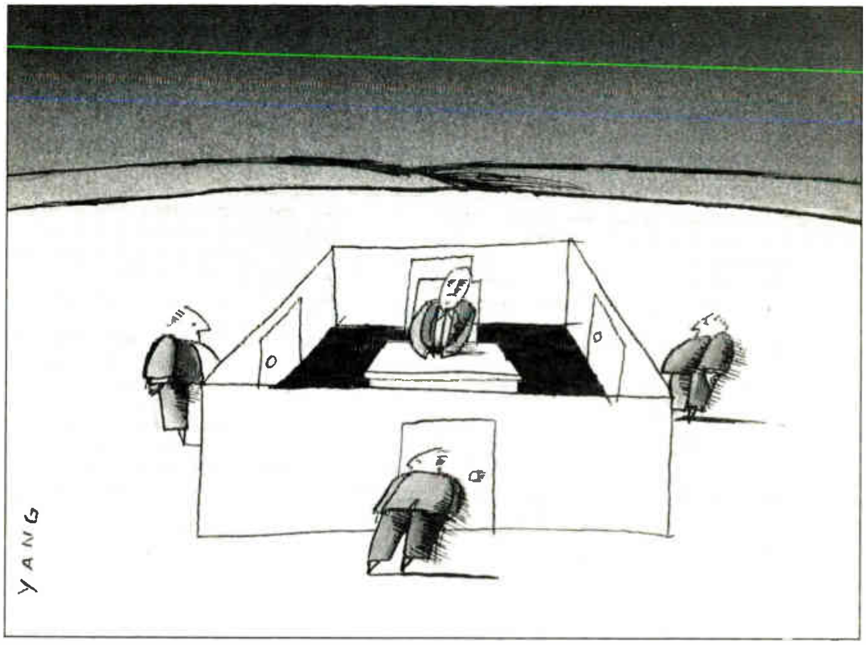
For additional information, please use the following Reader Service numbers: DESQview: #230 QEMM: #231 API Tools: #232 API Conference: #233

THE ROOT TO HAPPINESS

Having installed Unix, you can assign privileges and get down to working with the printer



In the last issue, I discussed some of the pros and cons of running Unix on a personal computer. I also outlined a brief scenario of installing Unix co-resident with DOS, using SCO Xenix as a practical example. In this and the next few columns, I'll go over some specific commands and procedures that you might find useful when setting up your system. Since I assume you have access to Unix manuals, I won't go into specific details of all standard Unix commands.

Getting Started

Once you have installed the Unix or Xenix system, you will find that you are running your system as the system administrator, with full *superuser* (also known as *root*) privileges. At this level, you can do essentially anything you want on the system, from running backups to reading other people's mail.

The system administrator has great power. As with any power, a certain amount of responsibility is needed, if for no other reason than because careless use of root privileges can wipe out an entire system in seconds. So you should get into the habit of logging in as root only when necessary to perform superuser functions, and then logging off. (Most of the procedures in these early columns will require you to use root privileges.)

Needless to say, you should carefully protect the root password, because anybody who discovers it can have free access to your system. But you should not protect it so well that you yourself forget it. Write it down in a safe place.

Much of the worry about needing root privileges can be negated by using one of the system-administration utility packages provided on many systems. On SCO Xenix, for instance, there is a good package called `sysadmsh`, which is a full-screen menu-based utility. (The `sysadm` log-in uses this shell exclusively.) In the long run, it pays to learn the details of the administration commands without the menu. Such knowledge allows you not only to get the most out of your system, but also to be able to use it on other versions of Unix, should you need to. While most versions of Unix are administered in the same general way, the menu systems are guaranteed to be entirely different. The selections in administration menus on different systems may have very different results than those you expect.

Adding Users

If the entire system is used only by you, there's no law that says you can't log in as root all the time, since that's essentially what you're always doing on a single-user system like DOS or the Mac. This method does make administration easier. Otherwise, the first thing you will probably want to do is give yourself log-in permission. But adding new users is a superuser function; you must be root.

The process of manually adding a user to the system is not really hard, but even experienced Unix system administrators prefer to use an automated process since there are many options and, therefore, many things to forget. Done by hand, you would have to add an entry to the `/etc/passwd` file containing the new user's log-in name, user ID number, group ID number, home directory, and log-in shell. If the user ID or log-in name matches anyone else's on the system, there will be problems, so these must be checked. The `/etc/group` file should be updated with the new user's real name. An initial password must be selected, and a home

continued

ILLUSTRATION: JAMES YANG © 1989

directory and mail file created and set to appropriate access permissions. Finally, a copy of your system's standard user `.profile` or `.cshrc` file should be placed in the new user's home directory and suitably modified, if necessary, for that user's terminal type. It's better to use the program to be sure all this is done. Many systems have a program called `mkuser`, `newuser`, or `adduser`, or a selection in the administration menu for this task.

The Joys of Printing

A Unix system with a dedicated printer is a joy to work with. You simply plug in the cable and copy a file to `/dev/lp`, and you're on your way. (On some systems the printer port may be called `/dev/lp0`, on others, `/dev/lp1`.) Want to do background printing? Just make your copy in background with a command like this:

```
cp filename /dev/lp &
```

(The & specifies that this is a background task.) Nothing could be easier. And although Unix has a wonderful line-printer spooling system, it can be annoying to set up and run, so I recommend that you leave well enough alone for starters (on small, single-user systems, at least). Once you start adding other users and processes that have to access your single printer, you can learn to run the spooler. Meanwhile, at least you'll have hardcopy output. Systems like SCO Xenix, with its `mkdev lp` script, greatly simplify spooler setup.

Serial printers are trickier, since the serial ports on a Unix system are usually set up for terminal log-ins, not printers. The trick here is knowing the default baud rate of a serial line, which in many cases is 9600 bps. Therefore, the first steps to take are: Set the printer to 9600 bps and disable the log-in on its port.

With SCO Xenix, to disable the log-in, you can simply type `disable tty2a`. Regular Unix is a bit more complicated; you have to edit the `/etc/inittab` file. A typical entry might contain the line

```
2a:2:respawn:/etc/getty
   tty2a 9600
```

and you want to change the word respawn (which means that a log-in process will be continally generated for that line) to `off`. The final step is to run the command `init q`, which forces the `inittab` to be reread, activating your new entry (and deactivating the port for log-ins).

Try directing a copy of a text file to the serial port (using `cat /etc/passwd > /dev/tty2a`), and see what happens. A printout of the password file means you got it on the first try. Garbled nonsense output, even a single character, is a good sign because it means that some data is getting to the printer but the baud rate on the printer doesn't match the port.

No output could mean that you are addressing the wrong port or that the transmit and receive pins (pins 2 and 3 on a regular 25-pin RS-232C connector) are switched. The best method of diagnosing this is with a through connector with LEDs that show data flow. If your computer is an AT compatible, you might try the port under DOS to make sure that the hardware, at least, is physically working.

> *A Unix system with a dedicated printer is a joy to work with.*

Baud Rate Blues

If your printer won't work when set to 9600 bps, you may have to force the printer port to 9600 bps or whatever your printer will accept. You have to create a small shell driver program that accepts a filename or standard input. While the program is active, it changes the port's baud setting; that is just what you want:

```
stty 4800 ixon -ixany ixoff   \
  -parity -echo clocal   \
  opost -tabs </dev/tty2a   \
  2>/dev/null
cat -
```

Everything after the baud rate is part of the set of options to the `stty` command. The three `ix` options ensure that the standard XON/XOFF protocol will be followed (your printer should be set up to match), `-parity` turns off parity encoding, and the other options tend to work well on printers. You must redirect the `stty` command *from* the device; this forces the settings to be in effect for that device, rather than for your current terminal port. Use this driver program by piping standard input to it, and then redirecting the output to your printer port:

```
cat /etc/group | drive_prog > \
   /dev/tty2a
```

Creeping Featurism

You can make the whole thing a bit neater by wrapping all this in a one-line shell program. If your printer is an Epson, call the program epson:

```
cat $* | drive_prog > /dev/tty2a
```

Now simply typing epson filename will print that file on your Epson printer. You can make things fancier by adding the pr command to the epson program to format the output into pages, create another command with the pr command built in, or use getopt to add capabilities to epson. This is how you begin customizing your system. (It's also the beginning of creeping featurism.)

Final Note

For regular users—not just root—to execute the programs drive_prog and epson, both must be marked as readable and executable, and placed in the default search path of the standard shell. As a regular user, if you type the one-line command echo $PATH, you will see a list of directories that the shell searches for executable files (minimally, the list generally contains /bin and /usr/bin). If you find the programs useful, type the following lines as superuser and then log out and back in as yourself to make them part of your system's repertoire:

```
chmod u=rwx,g=rx,o=rx  \
 drive_prog epson
cp drive_prog epson /usr/bin
```

The first line lets regular users use (but not modify) the two files. The chmod command must operate on three sets of permission bits, so its syntax can get complex. You could also write the same command as chmod 755 filenames; this does the same thing but operates directly in octal notation. The second line simply copies your programs to the system /usr/bin directory. To be safe, do an ls /usr/bin before typing the cp command, to make sure there are no programs of the same name already there.

In the next issue, I'll discuss modifying the search path so it will be in effect automatically for all system users. ■

David Fiedler is editor and publisher of the Unix newsletters Unique *and* Root *and coauthor of the book* Unix System Administration. *He can be reached on BIX as "fiedler."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.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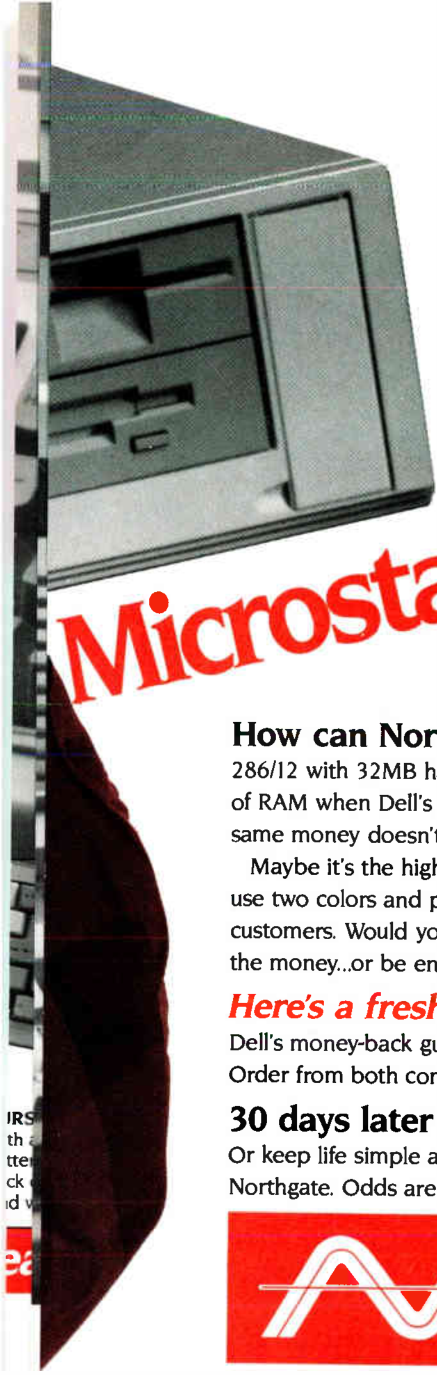

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Please complete all appropriate sections, providing at least two year's residence and employment history. This will enable your application to be processed as quickly as possible. If you are self-employed, please be sure to complete section "D" on back.

Applicants must be 18 years of age or older.

a. Your Personal Information

Requested Line of Credit $

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Present Address Street | Apt # | City | State | Zip | **Home Phone** ( ) –

Date of Residence: Month | Year | **Monthly Payment:** $ | Buy ☐ Rent ☐ Other ☐

Previous Address: | **Dates of Residence:** From | To

Your Employer: (If self-employed, see rear panel.) | **Date of Employment:** Mo. Yr. | **Position:** | **Monthly Income:** Gross $ | Net $

Employer's Address: Street | City | State | **Business Phone:** ( ) –

Previous Employer: | **Address:** | **Dates of Employment:** From | To

Income from alimony, child support or separate maintenance payments need not be disclosed if you do not wish to have it considered as a basis for repaying this obligation | **Other Income:**

I have received since (Date) | Monthly Income: Gross $ | Net $

Name and Address of Nearest Relative Not Living With You: | Relationship

b. Credit Information

Include joint applicant's information, if joint account requested.

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Bank Account:			☐ Checking ☐ Savings
Bank Account:			☐ Checking ☐ Savings

		Payment	Balance
Bank Loan Reference:			
Bank Card Reference:	☐ VISA ☐ Mastercard		
Other Credit Card Reference			
Other Credit References:	Account No.: Expires:		

Driver's License No. | State | Expires:

c. Joint Applicant's Personal Information

*If you are a married Wisconsin applicant, you must provide your spouse's information below, even though your spouse may not be signing this contract

Joint Applicant's Name: First | Initial | Last | **Date of Birth:** Mo Day Yr. | **Social Security Number:**

Address Street | Apt. # | City | State | Zip | **Date of Residence:** Mo. Yr. | **Home Phone** ( ) –

Employer: | **Date of Employment:** Mo. Yr. | **Position:** | **Monthly Income:** Gross $ | Net $

Employer's Address: Street | City | State | **Business Phone:** ( ) –

d. Self-Employed Information

Complete this section only if you are self employed

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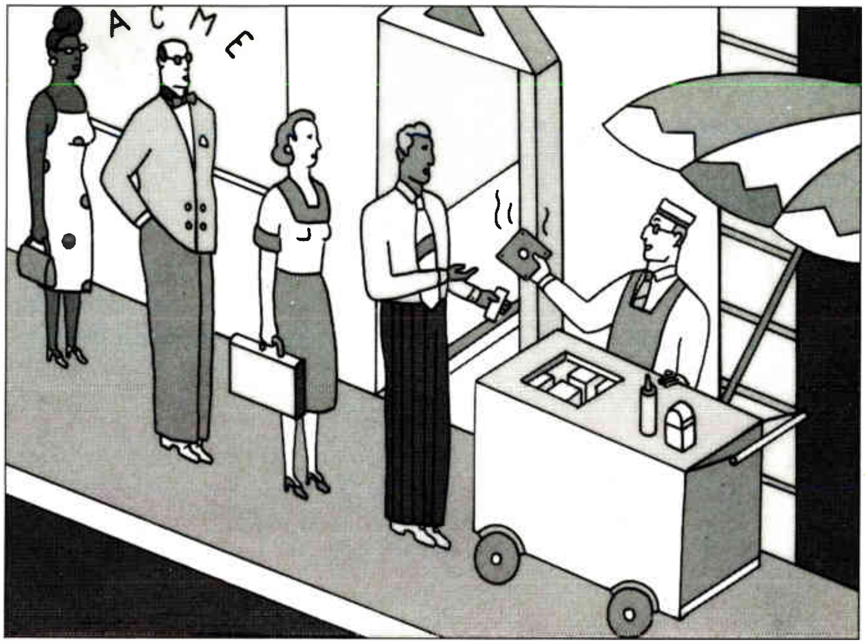

This month, I come to you from Milan, Italy. I'm here to teach a seminar on OS/2. I don't speak Italian, however, so the whole class is wired up like at the United Nations. After I speak, the participants dial a language to listen to, whether Italian or French or whatever. I've thought of taking my shoe off and banging it on the table to make a point, but I'm not sure the joke would be in good taste.

Last month, I talked to OS/2 applications developers. But where are the OS/2 applications? They are finally starting to appear. I recently received my copy of IBM and Microsoft's new edition of the *OS/2 Application Guide*. (You can get a free copy by calling (800) 426-2468, ext. 120.) The guide shows about 800 applications, roughly half of which are currently (as of June) shipping.

What does this tell us about OS/2 applications? Well, they're out there—and in places that you wouldn't expect. They include many industry-specific applications (more of those, in fact, than anything else), one being a $14,000 program that assists in designing microwave antennas. But OS/2 applications don't have to be expensive—one is under $18.

What Do They Do?

OS/2 applications are a pretty diverse lot.

There's a bunch of accounting programs—general ledger, accounts payable and receivable, inventory, payroll, order entry, and job costing. Accounting packages are not inexpensive—from $600 for the cheapest I could find (that's about 800,000 lira here in Milan) ranging up to a $2500 package that helps you track bad checks.

The business category yielded a few surprises. Recently, a researcher in Great Britain wrote to me looking for a large mass-storage device that works under OS/2. I'm an Iomega Bernoulli Box fan from way back, but unfortunately Iomega hasn't released the OS/2 drivers for the Bernoulli Box yet. (The company actually has the drivers finished; I understand there are some legal niceties to get out of the way before the drivers see the light of day.) So I had to tell the researcher to wait a little longer.

Advanced Graphic Applications has a better solution: Discus, a WORM (write once, read many times) controller board and drivers for OS/2. It's not cheap at $3600—and you have to add the WORM drive itself to the package—but the nearly limitless storage it provides could make it worthwhile for someone with truly large mass-storage needs.

Everyone knows about the weakness of the OS/2 print spooler, but I had no idea that someone had done something about the problem. Software Directions offers a "mainframe-style disk-based print spooler" (does that mean it requires lots of memory, needs a professional staff to maintain it, and you have to wait overnight for it to do anything?). It's called PrintQ and costs $199. It supports serial printers, too.

Asynchronous Renaissance

Asynchronous communications was once an important branch of PC software, and discussions of whether to go with PC-Talk, Crosstalk, or Smartcom were common at users group meetings. The market has pretty much settled down, with several packages each holding onto its share. But OS/2 was really made for communications. One of the best parts of using OS/2 is downloading BIX traffic in the background with Logicomm while working in the foreground on BRIEF. of these that I have mentioned Logicomm before, although it's not in IBM's guide.

continued

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Dave Briccetti and Associates
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Lafayette, CA 94549
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Inquiry 984.

PrintQ $199
Software Directions, Inc.
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(201) 584-8466
Inquiry 985.

Prolog $650
Arity Corp.
29 Domino Dr.
Concord, MA 01742
(508) 371-1234
Inquiry 986.

There is a new group of asynchronous programs, as the old masters haven't made an appearance yet.

For simple terminal emulation, file transfer, and general-purpose communications, there are ChipChat ($300), Hilgraeve's HyperAccess/5 ($199), and Professional YAM ($139). The only one of these that I have had a chance to try is HyperAccess. Matt Gray, president of Hilgraeve, is very convincing when he pitches the product. "We've been using OS/2 ideas like threads for years. We've implemented multitasking in our DOS version of HyperAccess, so porting to OS/2 was quite easy."

Gray says that in communications you spend a lot of time waiting. The Hilgraeve people implemented a block-oriented file transfer protocol that employs that waiting time to compress and decompress files on the fly. And it's pretty impressive. I consistently got 4000-bps throughput when using 2400-bps modems, even with the DOS version. As is the case with many companies, Hilgraeve ships both the DOS and OS/2 versions in a single package. This is a good idea in my opinion, at least for the time

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when the market is undergoing the transition to OS/2.

Another example of how multitasking and communications go hand in hand is with BBSes. For years, BBS operators have looked for ways to run their BBSes (which are usually not very memory-intensive operations) in the background while they're doing other things in the foreground. Just such a thing is possible with MichTron's BBS software. It, of course, supports multiple serial ports, as *any* OS/2 communications application would by definition. At $80, MichTron's product is already shipping and looks worth a try.

The final item in this category will appeal to members of electronic conferences, like BYTE's own BIX. When you start using BIX, you join a conference or conferences. For example, beekeepers might join the bee.keepers conference (I don't know if there is such a conference, but there could be—there are many conferences), or writers might join the writers conference. Some conferences are quiet, like ibm.at, which generates about 20 messages a month tops. Writers, on the other hand, can generate 20 messages an *hour*. Most of it is just chatter, but occasionally a nugget appears, like a useful phone number, book reference, or snippet of code.

When traffic is heavy, it would be nice to be able to save and categorize messages. Such a facility is offered by MsgVu. I tried an early version on BIX and truthfully didn't like it very much, but then I'm pretty crotchety about software. Once I find something I like, I tend to stay with it. Logicomm and Mirror serve me well in OS/2 and DOS, respectively. These programs *don't* keep track of messages, however—they just handle basic communications. MsgVu costs just $35, making it almost as inexpensive as Logicomm.

Accounting for the Databases

Databases weigh in at 82 products. *82 products?* Well, the number is a mite padded. Every accounting package on the market thinks it's a database. Even PrintQ, the OS/2 print spooler I mentioned earlier, groups itself here. Of course, all the big names are shipping already, except for Ashton-Tate.

Although, strictly speaking, Prolog is not a database (I'll get letters on that one, but it's true), Arity's Prolog for OS/2 is good news. My DOS Prolog classes are often hampered by limited memory space, as Prolog does a lot of searching to get its work done and creates huge data structures—all of which live in RAM—in the process of that work. Arity's DOS-based compiler and interpreter are among the best, so the OS/2 product will no doubt be a useful tool for professional Prologers.

I see I've run out of space already. So many packages, so little time. I'm trying to get some specifics on the new High Performance File System (HPFS) that's going into OS/2 1.2. I hope to be able to tell you about it next month. See you then. ■

Mark J. Minasi is a managing partner at Moulton, Minasi & Company, a Columbia, Maryland, firm specializing in technical seminars. He can be reached on BIX as "mjminasi."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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Model	Model 212M	Model 212	Model 325	Model 333	Portable III-212	Portable III-325
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RAM	512K 0 Wait	1 Meg 0 Wait	4 Megs Interleaved	4 Megs Cache	1 Meg 0 Wait	4 Megs Interleaved
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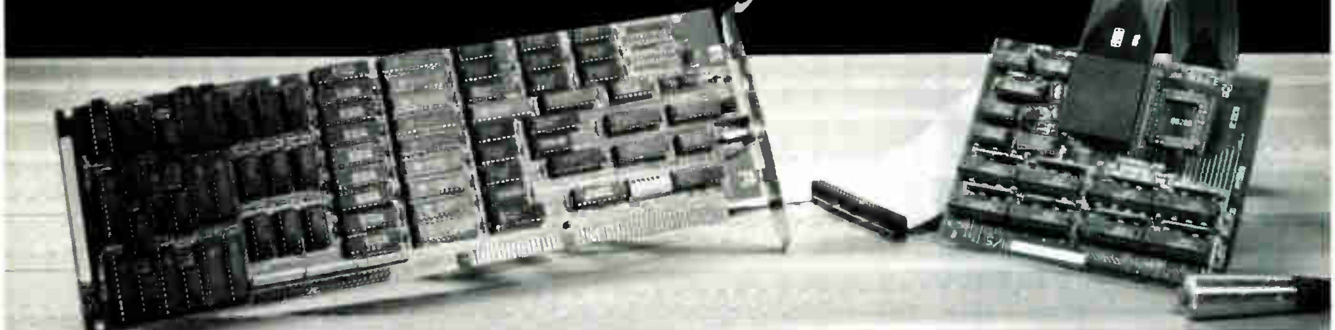

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PC Magazine, January 17, 1989

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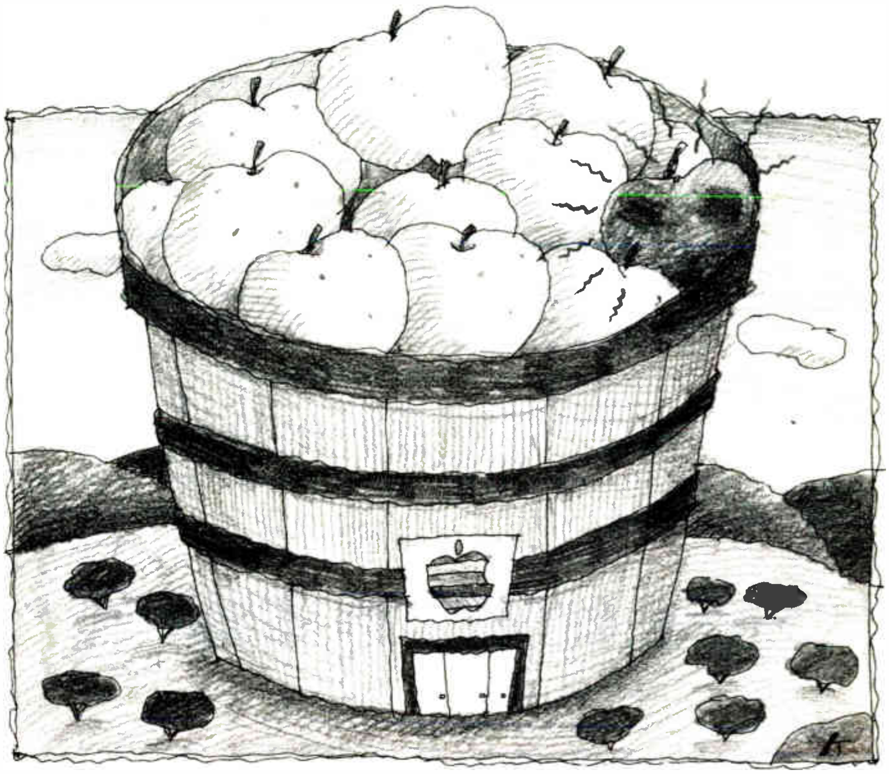

I am writing this column not long after someone stole and disseminated the source code to some of Apple's Macintosh ROM. As bad as this crime is (and let's make no mistake about it, this is a *crime*), the real tragedy is what it does to the people who work at Apple. People, many of whom are my friends and who have been loyal Apple employees for years, have come under suspicion. Apple has always been a tough place to work: too much hurry up and wait; too many changes in product direction, development, and marketing; and too many reorganizations. This latest incident just makes life tougher for Apple employees.

I'm appalled at the idiots who stole and disseminated this code and then had the gall to link themselves with some greater good. A criminal act is just that, no matter what the intentions might have been. Cloaking themselves in the banner of "open software" and spouting off about "freedom from the tyranny of proprietary operating systems" is a load of rubbish, nothing more.

These criminals have represented themselves as members of the nuPrometheus League. My hope is that when they are caught (and they will be, after many innocent Apple employees are harassed in the process), their punishment fits the crime. Recall that the Greek god Prometheus was chained to a rock for eternity by Zeus, while a vulture picked over his liver. I hope the nuPrometheus League meets a similar fate.

Don's Wish-List Macs

By all signs, Apple expects to make a big marketing push during the first quarter of its 1990 fiscal year, which will be starting about the time that you read this column. Rather than talk about the products that Apple expects to announce for 1990 availability, I want to push the discussion even further. It's time for me to unveil my Mac wish list. What do I want to see in new Mac products for 1990 and beyond?

The first Mac on my wish list is a natural: a new low-end computer designed to replace both the Plus and the SE. I've called this machine the Mac Classic before, and that's a name that befits its position in the product line.

The Mac Classic would have a modular design, based on the design-for-manufacturing (DFM) methods used in the IIcx. In order to make it easily transportable, it would consist of two units, one each for the CPU and the monitor, plus the keyboard. This could all be fastened together for carrying.

The CPU unit would contain a 16-MHz 68020 processor and single-in-line-memory-module (SIMM) slots for up to 8 megabytes of RAM. This unit would be the size of the current 80-megabyte external Apple SCSI hard disk drive, but it would weigh less. Its basic configuration would have 2 megabytes of RAM, so that System 7.0 would run (albeit without virtual memory). It would also have an FDHD floppy disk drive and a 20-megabyte small-format hard disk drive. Two Apple Desktop Bus (ADB) ports, two serial ports, a floppy disk drive port, a SCSI port, and a sound port complete the unit.

Oh, yes, there would also be a processor expansion port. Not an internal expansion slot. Forget that nonsense. The Mac Classic would be an information appliance, just like the original 128K-byte Mac. When you want to slice tomatoes with your food processor, you don't have to open the case and install a new motor (possibly damaging the components inside). You simply install a new blade.

continued

ILLUSTRATION: G. BRIAN KARAS © 1989

Likewise, you shouldn't have to open up your Mac Classic to install some new gizmo, like a floating-point chip.

This processor expansion port allows expansion doodads to be attached as easily as hooking up a second floppy disk drive or an external hard disk drive. Apple should sell an externally powered expansion chassis to hold multiple expansion boards, and it should encourage third-party vendors to create stand-alone accessories that would connect to the expansion port.

The monitor unit would contain the monitor's analog driver board and a 9-inch monochrome monitor. You would attach the monitor to the CPU box through some sort of sliding/docking catch that would incorporate the power and data connections (although separate ports would be available if you wanted to separate the CPU from the monitor with a cable). The mouse and keyboard would be one of the standard ADB keyboards that Apple now provides.

The Mac Classic would not have color or gray-scale capabilities built in (though they could be easily added), nor would it have many configurations, keeping in mind its price tag and its intended audience. The street price for the Mac Classic should be around $900, with pricing for students falling around $700.

This machine would replace the current Mac Plus and perhaps the SE, and it would likely sound the death knell for the Apple II line. Of course, these are all marketing reasons why Apple might not produce a Mac Classic or might delay its availability. Given IBM's premature dropping of its own AT system, Apple is likely to give market concerns more than mere lip service before unveiling any machine as tempting as my Mac Classic.

The Hyper Mac

OK, I admit it. I'm getting sick of Apple being handed its technological lunch by workstation vendors like NeXT and Sun. Don't get me wrong, I like the NeXT cube and the technology that it represents. And I wouldn't be able to get through a day without Midas, my trusty Sun-3/50NFS workstation. Then there are the new SPARCstations. These are impressive machines at impressively low prices. But they're still not Macs. The NeXT cube and the Suns won't run my huge library of Mac software. And their interfaces, while sporting many new and clever features, aren't as battle-tested and easy to use as the Mac's.

It's time to unleash a Hyper Mac! This would be a single-user machine running the Mac OS. Apple doesn't need to get involved in fighting Sun on Sun's terms. Sun has the Unix expertise and experience to win that battle, as the current nonsales of A/UX sadly point out.

The Hyper Mac would be a high-end machine capable of running existing 32-bit clean Mac software. It would be a six-slot machine, based on a new DFM design center that would clean up the existing Mac II family chassis and motherboard designs. As many components as possible would be surface-mounted to the motherboard, including the CPU. The chassis would also incorporate a beefed-up power supply, providing enough juice to power six NuBus cards without even flinching.

Now to the Hyper Mac's guts. Naturally, this baby will need a new ROM. Apple might as well make it a full megabyte, even if its software aces don't need all that space for now. The Hyper Mac's heart will be a very fast CPU, one that can compete with the likes of Sun's SPARC chip. Better make it a 68040 running at 40 MHz. Apple will want to toss in some kind of static RAM cache to optimize the performance of this fast processor.

There's no point in having this kind of raw computing horsepower tied to a 10-MHz NuBus. So the Hyper Mac will have a NeXT-class NuBus, running at least at 25 MHz, faster if the hardware gurus can pull it off. And direct memory access. Lots of it.

DMA is sorely missing on existing Macs and is one reason that real-time computing applications aren't being written for the Mac. The Hyper Mac's DMA channels will fix that.

How about RAM? Lots of it, virtual memory notwithstanding. We're talking minimum disk paging here. Thus, the Hyper Mac will have 16 SIMM sockets, for 16 megabytes of RAM when using 1-megabit-density SIMMs. Using 4-megabit-density SIMMs, the Hyper Mac could pack in 64 megabytes of RAM, enough for serious computing, even real-time stuff like shaded color animations that pump out 75,000 polygon transformations per second. Apple shouldn't sell the Hyper Mac with anything less than 8 megabytes of RAM.

How about an optical disk drive? Not yet. Apple should let NeXT and Canon

continued

You know exactly what your company wants in a color printer.

get those systems up to snuff in terms of speed and maybe include them in Hyper Mac II. For now, Apple should stick with small-format hard disk drives. The base configuration would come with one 160-megabyte unit, although the chassis could hold four, plus two FDHD floppy disk drives for quick backups and reading in data and software.

Anything else? The usual SCSI, serial, sound, and ADB ports. The SCSI port should have a faster transfer rate. Oh, and Apple should also throw in a better sound chip than its current Mac II sound chip, maybe a digital signal processor chip. In fact, I vote for a DSP chip.

And Ethernet. Not a NuBus slot-wasting Ethernet card, but built-in Ethernet on the motherboard. Make it thin and *thick* Ethernet, please (don't make NeXT's mistake on that one).

Is that it? Not quite. I'd also want built-in video. No more of this extra video-card expense. Apple should have built-in video with the same 8-bit high-resolution colors found on the SPARCstations. The built-in video should be capable of driving monochrome and RGB monitors, including full-page and two-page units. If you want 16- or 24-bit color, you could add a NuBus card loaded with video RAM.

Quite a machine, eh? Wait until you hear the price Apple should sell it for. Under $10,000 for a base configuration (19-inch monochrome monitor, extended keyboard, mouse, 8 megabytes of RAM, and a 160-megabyte hard disk drive). I can hear the screaming in Cupertino now. But consider the competition: The NeXT cube sells at Businessland for under $10,000, and SPARCstations can also be had in many versions for under $10,000. Those are the real price points the Hyper Mac must attack.

OK, Apple. There you have it. Two new machines on my Mac wish list. Building either one would reassert your technological prowess in the marketplace and capture sales now going to your competitors. Building both of them might just put some of your competitors back where they started: as niche vendors. ■

Don Crabb is the director of laboratories and a senior lecturer for the computer science department at the University of Chicago. He is also a contributing editor for BYTE. He can be reached on BIX as "decrabb."

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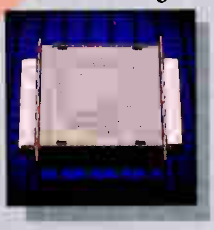

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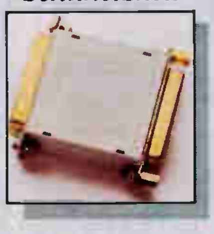

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IBM'S VISION FOR YOUR OFFICE

Is OfficeVision a glimpse of the future, or a blast from the past?

When IBM announced its Systems Application Architecture last year, it was clear that the company had some sort of grand plan, but it wasn't clear what the plan was. With the announcement of OfficeVision, the first collection of software for SAA, the plan's outlines have begun to appear.

OfficeVision is a collection of programs that support common requirements, much like those supported by Borland's SideKick. Unlike SideKick, however, OfficeVision also supports E-mail through a LAN or a mainframe, and it has a programming interface that allows other vendors to integrate their software into OfficeVision. It also has an address book, a basic word processor, a phone dialer, and a filer.

Next year's version will add more features, including the ability to support outside software. OfficeVision will have the same graphical user interface as Presentation Manager (PM). Eventually, the product will be available on every computer that IBM sells.

So what does this tell us about IBM's plans for the future?

First, IBM is committed to the infusion of personal computers throughout its corporate base. Personal computers (IBM would prefer you to use PS/2s) are an integral part of OfficeVision. The indication is that future applications will require personal computers to reduce the load on the mainframe processor.

Second, IBM believes that the LAN is here to stay. LANs provide the bulk of the communications required by SAA, and the first version of OfficeVision will be a LAN product. In the future, LANs will be even more necessary to SAA than they are now.

Finally, IBM still has its eye on the continuation of the mainframe as the backbone of corporate computing. Ultimately, SAA depends on data residing on a mainframe. This means that IBM plans to have data managed centrally by a data-processing department.

Personal Processing

Even though there will eventually be versions of OfficeVision for IBM's minicomputer and mainframe lines, IBM introduced it first in the personal computer marketplace, partly because of OS/2, which was intended for this purpose. It's also because OfficeVision requires some hefty computing resources that are more readily available on personal computers.

The first versions of OfficeVision will look familiar to current users of PM or Windows. The graphical interface will be the same, and it will be controlled by a mouse in the same manner. These processes are heavy users of the CPU, however, so it will take some time for IBM to tune them for use by terminals on their mainframes.

The first version of OfficeVision to be introduced will be called OfficeVision/2 LAN. The introduction for this version, scheduled for last month, should have taken place by the time you read this. This version is designed for machines using OS/2, and it will communicate with others using a Token Ring LAN. Later, there will be support for Ethernet when OS/2 Extended Edition 1.2 is shipped in January 1990.

LAN Connection

OfficeVision is designed to work with a LAN. The E-mail capability in the initial version depends on it, and future releases will depend on it more. As SAA and OfficeVision software progress through their development, they will depend on

continued

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data stored on mainframes and minicomputers.

Currently, OfficeVision will support only IBM's Token Ring network. It's a safe bet that other companies, including 3Com and Novell, will find a way to support OfficeVision, too. In the meantime, OfficeVision/2 LAN will also quietly support DOS machines. IBM has worked with Consumers Software of Vancouver to develop MS-DOS workstation support for OfficeVision.

LAN usage becomes more critical with software such as Executive Decision/VM. This package is designed to run on both a mainframe running in a virtual machine environment and a personal computer running OS/2. Executive Decision is a true SAA application. It runs on the personal computer, but it uses a LAN to reach a mainframe where the data is actually stored. As a result, the personal computer never really has the data available internally. Instead, it extracts what it needs from the corporate database on the mainframe.

Central Storage

Eventually, this centralized storage is what IBM intends for the majority of the computing environment. There are some sound marketing and business reasons for this. Simply put, IBM's plan puts the corporate data-processing department in charge of the data again.

The concept is simply this: The personal computer would become an "intelligent workstation." Processing would be shared between the workstation and the central computer. While there may be some local data storage, most data would reside on the central mainframe. The SAA software on the workstation would find the data it needed, wherever it was. The user would never know where the data was kept or how it was found.

Let's say, for example, that you were working with employee records to determine pay raises for the next year. The information might come from personnel data on an AS/400, financial data from the corporation's 3090, and employee performance data from a database server on the LAN. The application would send out Structured Query Language (SQL) queries to each of the three databases.

When the response comes back, the software on the workstation will present it in a single picture. You would have no way to know that three computers were queried. In fact, you'd probably have no way to query those computers directly.

The data used for the queries would remain in its respective databases. It would not be transferred to the personal computer, and the databases could not be manipulated unless that capability was given to a specific user.

ITEMS DISCUSSED

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Corporate Safety

From the viewpoint of the corporation's management, this change is a distinct improvement over today's situation, where the corporate data is spread among literally thousands of personal computers. There, the corporation has no way of ensuring that important data is safe and properly backed up. In addition, it has no assurance that the data is up-to-date or correct. Management decisions are being made with data that may be corrupted or outdated, and data vital to the operation of the corporation may be lost through something as minor as the failure of a $200 hard disk drive.

Clearly, corporate management prefers greater control over the company's information than is frequently the case now. Unfortunately, until very recently, there has been no way to provide this. There simply weren't any good ways to consolidate the corporation's data so that it would be secure yet still available to personal computer users when needed.

Now that LANs and SQL have been teamed, that bottleneck is no longer a problem. Users can access a mainframe database almost as easily as they can access data on their personal computers. The only problem is that frequently the methods for doing so are proprietary.

The proprietary nature of these databases is, of course, part of IBM's plan. The idea is that you would have to buy an IBM brand of central computer along with your IBM PS/2. They would be linked by an IBM Token Ring LAN.

This process would continue as development of SAA continues. More and more applications would use central databases for all their data. This would include programs that today use mostly local storage, such as spreadsheets and word processors. You would have the ability to draw from vast corporate resources, but you would be controlled by a central data-processing department.

From IBM's point of view, this is ideal. Companies would come to depend more and more on central mainframes, while at the same time buying more and more personal computers. Everybody benefits, except perhaps the user who may need something that IBM isn't selling. Particularly frustrated by this situation will be small businesses that don't have the resources to buy an IBM mainframe. Those users will simply be left out in the cold by IBM's solution.

Third Parties

Fortunately, there is a SQL world outside of IBM. SQL servers are available from Oracle, Ashton-Tate, Gupta Technologies, and WordTech. SQL databases are available for minicomputers and mainframes from a variety of sources besides IBM. In short, as the benefits of SAA become clear, there will be a way to achieve them outside of IBM.

In fact, most of the benefits of SAA can be achieved without using a central mainframe at all. LAN-based database servers will handle virtually all the same operations as a mainframe DBMS and will permit control of the database to remain with the individual department. New advances in data archiving will let these servers be protected and backed up in much the same way as a mainframe but without requiring a mainframe's staff.

Clearly, SAA has much to offer corporate users. Most important, it offers security of data. After all, the data does belong to the corporation, and it is in the corporation's interests to protect it. That this can be done without moving to IBM as a sole supplier probably ensures that it will happen all the faster. What is missing is a middle ground. Not everyone and not every company needs or can support a minicomputer or a mainframe. At this point, IBM's solution will freeze them out of SAA. ■

Wayne Rash Jr. is a contributing editor for BYTE and a member of the professional staff of American Management Systems, Inc. (Arlington, VA). He consults with the federal government on microcomputers and communications. You can contact him on BIX as "waynerash," or in the to.wayne conference.

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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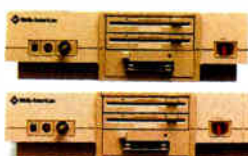

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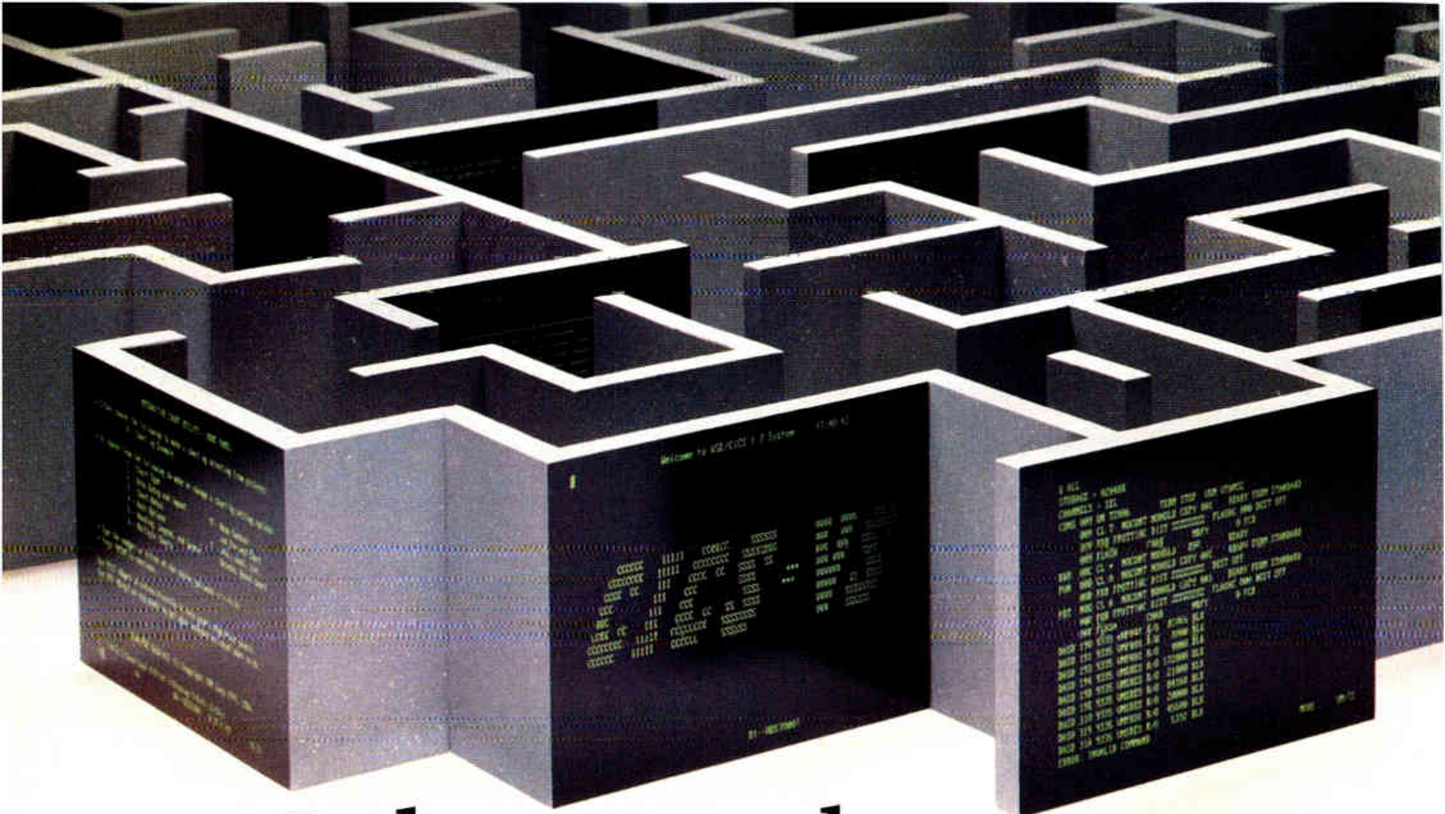

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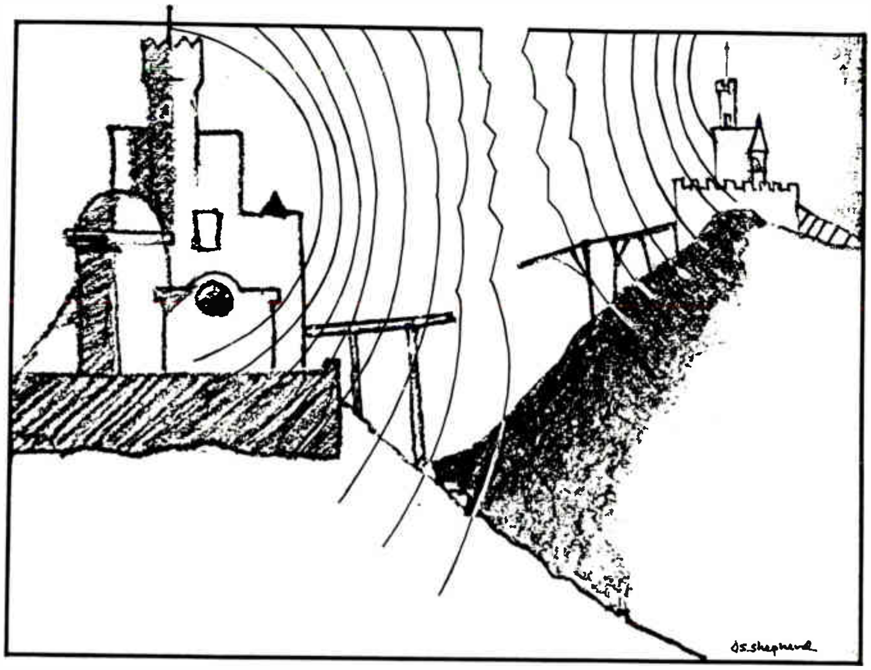
BREAKING DOWN THE BARRIERS

There are three approaches to linking PCs and Macs on a LAN—here's our favorite



There are many cultural barriers that make it difficult to integrate such diverse systems as Macintoshes, IBM PCs, Sun workstations, and DEC VAXes on a LAN. This month we look at a few of the issues you'll face and some products you might want to consider if you try to integrate the two most common types of microcomputers: PCs and Macs.

The first step toward PC-to-Mac communications is to connect the systems physically. You have two choices: You can use the Mac standard by buying LocalTalk boards for your PCs, or you can choose a common PC connection, Ethernet, and buy Ethernet adapters for your Macs.

Unfortunately, hooking up heterogeneous systems requires much more than just a physical connection. You've still got to make both systems speak the same language—which, in this case, is the same higher-level protocols. Those protocols are typically the ones that a LAN operating system provides.

Speaking the Lingo

A LAN operating system that integrates heterogeneous systems must follow one of three basic approaches.

In one method, the LAN can force one system to talk the lingua franca of the other. Apple's AppleShare PC follows this approach. You put a LocalTalk card in your PC and wire the PC to your Mac network, and then the PC can access files on the Mac AppleShare file server. The problem with this method is that one kind of system will need to abandon its native environment.

Another approach is to create a new LAN operating system, a sort of LAN Esperanto, and then implement that new system on both the Macs and the PCs. The TOPS LAN operating system, from Sun Microsystems, works this way. TOPS can run over either LocalTalk or Ethernet, and it doesn't require a dedicated server—both PCs and Macs can share files with the other systems on the LAN. The major drawback of this approach is that it typically doesn't use the native protocols of either system. TOPS, for example, doesn't presently support the AppleTalk Filing Protocol (AFP) on the Mac.

The third method is a compromise: Each system speaks its own "language," or native protocols, and a third party translates between those protocols. Novell's NetWare for Macintosh employs this technique. PCs use the NetWare LAN operating system, while Macs use their standard AFP services.

We believe that this approach, which essentially says, "Stick with what you know, and let a translator do the work," is the right one for most applications. Since Novell has the best implementation of this approach so far, we'll take a closer look at NetWare for Macintosh.

NetWare for Macintosh

NetWare for Macintosh is a translator, or gateway, that runs in a NetWare 2.15 server. Because NetWare uses Novell's proprietary NCP (NetWare Core Protocol) protocols internally, this gateway translates between NetWare's IPX (Internet Packet Exchange) and the AppleTalk protocols that the Macs require. It has five main components.

The LAN board and its driver implement the LocalTalk or EtherTalk protocols and the actual hardware interface. While you install either board with NetWare's standard NETGEN program,

continued

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neither one actually uses a valid NetWare LAN driver. Instead, NetWare never really sees the board. A NetWare Value Added Process (VAP) works with the board; NETGEN creates a stub for the hooks to that VAP.

The next component provides three of Apple's protocols—the Datagram Delivery Protocol (DDP), the AppleTalk Transport Protocol (ATP), and the AppleTalk Session Protocol (ASP)—on the NetWare server. NetWare for Macintosh needs these protocols to match the standard AppleTalk protocol stack. (See the July NetWorks column for more information on these protocols.) Next up the protocol stack is NetWare for Macintosh's AFP VAP. It uses these lower-level protocols to act just like any other AFP server. Macs on the LAN can't distinguish this AFP VAP from any other AFP server.

The final piece of the puzzle is the Service Protocol Gateway (SPG), which translates between AFP requests from the AFP VAP and requests in the NCP format. Once the requests are in the NCP format, NetWare NCP can handle them just as it would handle NCP requests from a PC.

Tracing the Path

The easiest way to understand how all these pieces work together is to look at an example. Consider a file request from a Mac. First, the Mac user brings up the Chooser, selects the NetWare for Macintosh server, and logs onto it. The server's icon appears, and the user treats it like any other disk; to get a server file, the user double-clicks on that file.

The Mac AppleShare client software then goes to work. It requests the contents of the file using AFP. The AFP packet flows down through the usual ASP, ATP, and DDP layers and finally ends up on the LocalTalk wiring.

When the packet reaches the NetWare server's NL1000 LocalTalk board, the server takes over. It sends the packet up through the driver, DDP, ATP, and ASP layers to the AFP VAP. The AFP VAP hands the request to the SPG, which translates it into an NCP request. NCP gets the file and sends the data back through the reverse path.

Icons and Resources

The beauty of this technique is that the Mac never knows that the file isn't on an AppleShare server. NetWare for Macintosh uses the standard AppleShare client software on the Mac.

Presenting that illusion isn't easy. One big difficulty stems from the way Macs store files: A Mac file actually has two underlying files, a *data fork* and a *resource fork*. The data fork holds the file's data, while the resource fork contains such related items as icons and dialog boxes. Every Mac file must have these two components.

DOS files, of course, don't meet this requirement, and therein lies the problem. TOPS gets around this problem by using a Desktop file in every directory that contains the resource information for all the PC files in that directory. Similarly, NetWare for Macintosh uses a Desktop directory on the server to store the information for resource forks and icons for DOS files. Those files appear to the Mac user with a special DOS icon.

Print Services

AppleTalk also lets you share printers, so NetWare for Macintosh offers the same services. Instead of using an AFP VAP and SPG, however, it contains a corresponding AppleTalk Print Server (APS) VAP that lets a Mac user either queue print requests on the NetWare server or talk directly to the printer.

The APS VAP implements queuing by appearing to the Macs as a LaserWriter. When Printer Access Protocol packets from a Mac arrive at the server, they go up through the DDP and ATP layers to the APS VAP. The APS VAP then translates those requests into NetWare print queue requests. Then, when the NetWare print queue manager is ready to send a print request to the LaserWriter, it hands that request to the APS VAP. The APS VAP then acts like a Macintosh and sends the print job to the LaserWriter.

PCs can also use NetWare's standard printing facilities to queue up PostScript files for printing on the LaserWriter—so PCs and Macs can share a LaserWriter courtesy of NetWare's print queue.

Finally, Macs on the LAN can bypass the server and send print requests directly to the LaserWriter, although those requests will then not be in NetWare's print queue.

If a Mac user wants only the standard AppleShare client software features, then NetWare for Macintosh is happy to oblige. NetWare for Macintosh does, however, offer a few additional utilities for venturesome Mac users. The most interesting one is the Rights desk accessory, which lets Mac users manipulate NetWare's large set of file protections.

Almost There

With all these tools, you're almost done, but not quite. You still need applications that can either use files on both Macs and PCs or at least translate files between the two systems. Currently, only a few such applications exist, although more are appearing all the time.

One such application is Microsoft Word. We had some PC Word files on our 80386-based Samsung NetWare server. We decided to go for the gold and started Word on the Mac on one of those files. No problem; the Mac Word program recognized that the file was from a PC version of Word, translated the file automatically—without losing any formatting—and we were in business.

Unfortunately, if we had tried opening a WordStar file from MacWrite instead, we wouldn't have been as lucky. The greatest integrated LAN operating system in the world isn't much good if your applications can't take advantage of files from different machines.

A Look Ahead

NetWare for Macintosh is impressive, but it does have a few problems. There are, for example, several bugs in the print spooling code. Other problems have prompted Novell to suspend product shipments temporarily. (The product should be shipping again by the time you read this.)

More frustrating, however, is the product's immediate future. The design of Novell's new NetWare 386 version 3.0 supports a cleaner integration of products, such as NetWare for Macintosh, than does the design of NetWare 2.15. Sadly, the initial release of NetWare 386 doesn't support NetWare for Macintosh. If you want both the new features of NetWare 386 and the power of NetWare for Macintosh, you'll have to wait.

Still, the next year should be a good one for products that link heterogeneous systems. Token Ring Mac boards are becoming available. Competition in the LAN operating-system arena will heat up as TOPS and 3Com bring out strong new offerings with AFP support. Finally, more and more major applications now offer both Mac and PC versions, with some way to share files between those versions. The barriers, it seems, are slowly falling down. ■

Mark L. Van Name, a BYTE consulting editor, and Bill Catchings are independent computer consultants and freelance writers based in Raleigh, North Carolina. You can reach them on BIX as "mvanname" and "wbc3," respectively.

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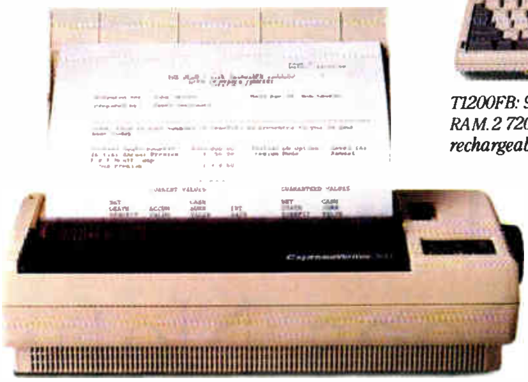

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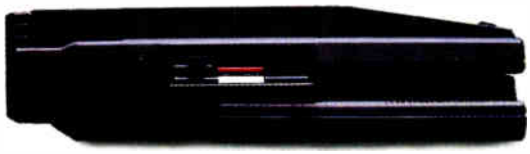

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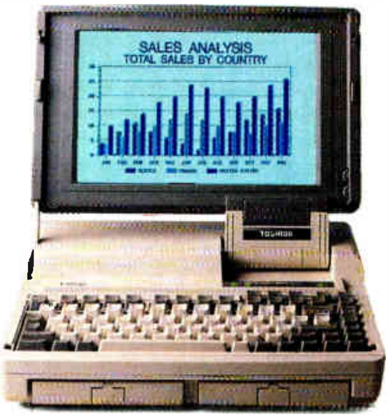

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The Optical Option

WORM and erasable optical drives offer practical solutions to large-scale storage requirements

Steve Apiki
and Howard Eglowstein

Optical storage technology sounds like science fiction, but using a laser beam to put hundreds of megabytes of data on a disk cartridge that fits into your hand has become a fact. Beyond the technology's Buck Rogers appeal lie practical, real-world devices that answer today's mass-storage requirements.

Optical drives—WORM (write once, read many times) and rewritable systems—are the most appealing, most elegant method yet devised for storing vast amounts of data. But these cutting-edge products have their limitations. Access times, while steadily improving, remain well behind those of magnetic drives. And the relatively high cost of optical drives has made them unacceptable for everyday use.

However, the current trend toward monstrous operating systems, shared databases, and more realistic visual images on disk may shift the economic balance in favor of optical storage. As files get ever larger, optical storage gets more and more appealing—no technology can compete with optical disks when you're measuring backup or even day-to-day requirements in gigabytes.

This month we focus on nine WORM and four rewritable optical disk drive systems available for both Macintosh and IBM PC-compatible computers (see table 1). All are full-height units that use 5¼-inch removable media cartridges with capacities of from 600 megabytes to more than 1 gigabyte. Many of the packages are resold versions of the same drive or controller bundled with different driver software. To make the most meaningful comparisons, we evaluated each product as a complete system.

WORMs vs. Erasables

WORMs and erasable optical drives both use lasers to pack information densely on a removable disk. But beyond that, they have little in common. The two technologies use different media, incorporate different recording and reading schemes, and have different uses (see the text box "Optical Technologies" on page 168).

WORM drives were the first type of writable optical storage device to become widely available; 5¼-inch drives were available as early as 1985. As the name implies, you can write to each disk only once, and you can't erase data stored on a WORM. This natural data permanence makes WORMs ideal devices for archival backups. They're well suited to situations in which permanent records are required by law; for example, an insurance company might use a WORM to save scanned reports. Another application might be at an engineering design firm that requires a permanent record of all design revisions.

Because of their huge capacity and relatively fast random-access retrieval capability, WORMs are also useful for general archival storage. While WORMs are, by nature, sequential write devices, vendors have gone to great lengths to make them emulate random-access write devices. As such, they're useful for incremental backups or for storing databases that must be regularly updated.

Erasable optical drives are a more recent development, and few are available. Erasable units are ideal for backups. Since you can remove and reuse them, they provide virtually limitless storage capability. Although too slow to be direct replacements for magnetic disks, erasable optical drives are functionally equivalent, and you can use them with almost any applications software.

Unlike WORMs, where competing formats make data interchange a remote possibility, the prospects for a standard for rewritable optical disk technology look good. The International Standards Organization (ISO) is in the final stages of issuing a formal standard, and manufacturers are working toward conformance. ANSI has an identical standard on the table. Although standards will allow data interchange between different manufacturers' products, data interchange is all but impossible between currently available units.

The Speed of Light

We tested the WORM and rewritable drives on two platforms: a 20-MHz Compaq Deskpro 386 and an Apple Macintosh IIcx. We installed each drive according to the manufacturer's instructions. Some PC software provided for either a RAM or magnetic disk cache. Where possible, we accepted the manufacturer's default values for cache size.

Our tests examine optical drive performance in three areas: as a backup device, as a large general-purpose disk, and as a medium for document storage and retrieval. The raw results for each test are shown in table 2. Graphs of these results appear in the figure. The bars in each graph are normalized against magnetic drives running on the appropriate machine; on the DOS side, we used Compaq's 120-megabyte ESDI hard disk drive, and on the Mac we used the Mac IIcx's 80-megabyte internal hard drive.

For the backup test, we copied a large directory structure from the system's primary magnetic drive to the optical drive. The test data was a 25-megabyte

continued

A collection of WORM drives

Left side: ISi 525GB, LaserDrive 810-111

Center, top to bottom: Maximum Storage APX-4200, Pioneer DD-S5001, SDI LaserStor 800, SDI LaserStor for Macintosh, Corel 800

Right side: Corel 940, LaserDrive 820-011

PHOTOGRAPHY: PAUL AVIS © 1989

Table 1: *Both WORM (write once, read many times) drives and rewritable drives are available in a range of capacities and prices. Unless otherwise noted, prices do not include media. Note that average access times provided by vendors didn't always correlate with our benchmark results in table 2.*

	Operating platforms	PC subsystem price	Macintosh subsystem price	Cartridge price (double-sided)	Formatted capacity per side (megabytes)	Format method	Average access time (milliseconds)	PC utility software[1]
WORM devices								
Corel 800	PC, PS/2, Macintosh	$3645[2]	$3645[2]	$145	400	CLV	168	Retrieval and backup
Corel 940	PC, PS/2, Macintosh	$3695	$3695	$160	470	Modified CAV	90	Retrieval and backup
ISi 525GB	AT	$6288	N/A	$350	640	CAD	110	Retrieval and backup
LaserDrive 810-111	PC, PS/2	$5495	N/A	$200	405	CLV	175	None
LaserDrive 820-011	Macintosh	N/A	$5995	$200	[illegible]	[illegible]	[illegible]	N/A
Maximum Storage APX-4200	PC	$4450	N/A	$195	380	CAV	28	Version retrieval
Pioneer DD-S5001	PC, Macintosh	$3895	$3695	$145	327	CAV	77	Retrieval and backup
SDI LaserStor for Macintosh	Macintosh	N/A	$4999	$150	366	CLV	168	N/A
SDI LaserStor 800	PC, PS/2	$4495	N/A	$150	393	CLV	168	Version retrieval, cache utilities
Rewritable devices								
AGA Discus Rewritable DR650	AT, PS/2, Macintosh	$6495	$6495	$250	325	CAV	61	None
RACET Cosmos 600	AT, Macintosh	$5645	$5590	$298	297	CAV	67	Security utilities
Sumo Systems RSSM600-B	PC, Macintosh, Sun, DEC VAX	$4700	$4500	$260	297	CAV	50	N/A
Summus LightDisk-650	AT, Macintosh, Sun, DEC LSI, VAX, MicroVAX	$6495[2]	$5495[2]	$250	297	CAV	132	None

CAD = Constant area density
CAV = Constant angular velocity
CLV = Constant linear velocity
N/A = Not applicable

[1] Utility programs in addition to drivers, format utilities, diagnostics, and other required software.
[2] Price includes media cartridge

directory with many levels of subdirectories or folders and files of varying length scattered throughout. The PC tests used XCOPY to transfer the entire structure from the magnetic drive (see the backup write times in table 2).

Because WORMs can't erase data, they must use linked lists or similar schemes to point to file updates. This often results in longer read times for successive versions of a file. Incremental backups, a typical use for WORMs, force this condition.

The backup read test incorporates incremental backups. It does a total of five XCOPYs from the optical drive to the magnetic drive, with a partial backup after each. The partial backup uses XCOPY/M to update the disk with 5 megabytes of unchanged files. We timed each XCOPY of the full directory from the optical drive to the magnetic disk and averaged the results.

As a check on the efficiency of directories, we timed searches through the data structure for a nonexistent file, using the Whereis utility from Apple's Macintosh Programmer's Workshop (MPW) 3.0 on the Macintosh and a BYTE Lab utility on the PC.

Macintosh utility software[1]	Operating-system compatibility
Version retrieval	MS-DOS 3.0+, Mac OS
Version retrieval	MS-DOS 3.0+, Mac OS
N/A	MS-DOS
N/A	MS-DOS 3.0 - 3.3
None	Mac OS
N/A	MS-DOS 3.0+
Version retrieval	MS-DOS 3.0+, Mac OS, Novell
Version retrieval	Mac OS
N/A	MS-DOS 3.0-3.3, Compaq DOS 3.31
N/A	MS-DOS 3.0+, Mac OS, OS/2
Security utilities	MS-DOS 2.0+, Mac OS, TOPS, AppleShare, Novell Advanced NetWare/286 2.15
None	MS-DOS 2.0+, Mac OS, BSD Unix 4.0, VMS
None	VMS, VAXELN, Ultrix BSD UNIX 4.3, RT-11, RSX-11, RSTS/E MUMPS, Mac OS 4.2+, System V, MS-DOS 3.0+, Sun OS 3.5+

The Macintosh provided us with a particularly interesting challenge: The operating system has no equivalent to XCOPY. The Macintosh Finder has no provision for incremental copies. Simply clicking on the structure and dragging it from one disk to another will do the initial copy, but that's all.

The Finder still retains a few bugs that have been hanging around for some time. Trying to click and drag on our 25-megabyte structure resulted in repeatable Finder errors; the Mac kept complaining that some files were unreadable. Checking back, we found that a Mac SE with System 4.1/Finder 5.5 produced the same results as our Mac IIcx's copy of System 6.0.3/Finder 6.1. We completed the backup tests with the Backup facility in MPW.

If you were to open a large database file on a magnetic disk and make updates to it, the modified file would take up the same amount of space as the original. WORMs, on the other hand, must allocate new storage sectors to replace the old. Despite the wasted sectors, judicious updates on a large file can still be a legitimate use for a WORM drive. We tested the random-access capability of both WORMs and magneto-optical drives with a 20-megabyte database and a test program written in dBASE III Plus 1.1.

For each of five iterations, we made simple modifications to every one-hundredth record and then performed a nonindexed search. After indexing the data, we performed the same search in indexed mode. Table 2 shows the times for the sequential search and the index; the indexed search is not shown because it took too little time to yield meaningful results. FoxBASE+/Mac 1.0 took the same script that we used on the PC and executed it flawlessly on the Macintosh.

Our third test simulates drive use in a storage/archival application. An example would be the archiving of digitized claim forms in an insurance company. We digitized a full page of graphics at 300 dots per inch and stored it on the drive as a TIFF file. Using the image editors that come with Hewlett-Packard's Scanning Gallery (for the PC) and the Apple Scanner (for the Mac), we made four simple modifications to the image, saving it under the same filename between each modification. We noted the times for each read and subsequent file write.

This test allowed us to try out another exciting feature of WORM technology: the ability to retrieve old versions of previously deleted or updated files. Those drives equipped with version-retrieval software made it possible to retrieve the original file as well as the intermediate modifications. Generally, getting these older versions back involved running a special utility to return the directory system on the drive to the state that it was in immediately after the desired version was written. Rewritable drives lack the capability to retrieve previous versions.

Our last test was a qualitative evaluation of MS-DOS compatibility. The test program simply sequenced through a series of calls, trying each of the MS-DOS INT 21H disk functions. We'll discuss exceptions to the generally high degree of compatibility in the product overviews that follow.

The WORMs

In evaluating optical drives, capacity and speed are key considerations; but price, software capability, and efficient use of media often play important roles as well.

Your anticipated storage requirements are important; if you have a good idea of how much space you'll need, you'll be able to make an accurate price comparison based on cost per megabyte. If you plan to use an optical device for other than archival storage, consider whether you will need to back up the optical disk itself. Finally, if you need an optical device to back up your Macintosh, make sure that the backup software you select has the capabilities that you need.

Corel 800

Corel Systems is primarily a software company, but it bundles a variety of manufacturers' drives with its software and third-party interface cards to form complete drive subsystems. The Corel 800 subsystem uses the 800-megabyte Ricoh WORM drive and is available for both DOS and Macintosh environments; both versions cost $3645.

On the PC, the system includes a Future Domain SCSI card and cable. Setup and installation are straightforward: Corel provides both a comprehensive, but generic, software and installation manual and a slim installation guide with Ricoh-specific details. The software manual also includes an in-depth programming section.

The Corel drive was the slowest WORM we tested on both the PC and the Macintosh, but it responded properly to all the DOS 3.3 disk calls we tried.

Corel's DOS driver maintains a small disk cache in system memory. We tested with the default cache size (four sectors), but the size is user-selectable. The driver takes care of the physical-to-logical-sector mapping required to make the optical drive look like a random-access write device. When DOS requests a sector write, the driver maps that sector to a physical sector and updates the translation tables. The translation tables make it possible to rewrite logical sectors even though you can't modify physical sectors. The software writes the translation tables to disk every so often as part of its *history*

continued

Table 2: *Benchmark times (in minutes:seconds) for WORM (write once, read many times) drives and rewritable drives. We've included benchmarks for the Compaq Deskpro and Mac IIcx magnetic drives for comparison. Optical drives, on average, took about twice as long as magnetic drives to complete the same task. (See the figure for corresponding graphs.)*

PC tests	25-Mb backup write	25-Mb backup read	Directory search	50,000-record database search	50,000-record database index	1-Mb image write	1-Mb image read
WORM devices							
Compaq 120-megabyte ESDI disk drive	10:43	7:22	0:11	2:01	9:00	0:11	0:12
Corel 800	35:21	20:57	0:23	16:48	37:46	1:16	1:39
Corel 940	14:12	11:13	0:09	6:10	13:28	0:16	0:1
ISi 525GB	50:40	12:35	0:13	4:11	10:51	0:25	0:11
LaserDrive 810-111	21:16	17:37	0:19	16:23	24:49	:23	0:2
Maximum Storage APX-4200	17:04	13:40	1:18	N/A	N/A	0:19	0:11
Pioneer DD-S5001	15:03	12:33	0:13	7:36	14:25	0:18	0:15
SDI LaserStor 800	46:02	33:51	0:14	18:17	29:34	1:37	0:20
Rewritable devices							
AGA Discus Rewritable DR650	26:29	8:22	0:05	3:35	8:39	0:15	0:11
RACET Cosmos 600	39:54	12:51	0:12	6:42	15:04	0:29	0:14
Summus LightDisk-650	34:55	14:26	1:00	17:24	45:04	0:16	0:1
Mac tests							
WORM devices							
Macintosh IIcx 80-megabyte hard disk drive	12:26	3:56	0:09	1:26	2:52	0:11	0:01
Corel 800	30:07	7:50	3:36	13:03	15:05	1:44	1:37
Corel 940	12:39	4:48	1:02	5:18	6:10	0:21	0:1
LaserDrive 820-011	29:57	4:06	0:26	8:34	8:21	3:44	0:17
Pioneer DD-S5001	13:01	4:31	1:49	5:57	6:38	0:19	0:1
SDI LaserStor for Macintosh	29:54	7:36	2:28	12:56	14:07	1:47	1:31
Rewritable devices							
RACET Cosmos 600	25:29	5:50	1:46	3:51	4:48	2:52	0:13
Sumo Systems RSSM600-B	25:44	5:45	1:44	3:50	4:39	2:48	0:13
Summus LightDisk-650	19:02	4:06	0:25	3:39	4:31	1:01	0:13

N/A = Not applicable

markers. It updates these markers after a given time interval or after a number of write requests have transpired.

History markers make it possible to recover older versions of updated files. Corel's History utility lets you return to old versions either by specifying filenames or by locating any previous history markers. While this allows you to read old versions, you can't write to the cartridge in that state. If you need write access to an old file, you must make the old history marker current; this returns all files on the disk to the state they were in when that history marker was written. Except for Maximum Storage's APX-4200, all WORM version utilities work in a similar fashion.

Corel also provides diagnostic, format, and miscellaneous drive utilities. DOS patch software lets you use large partitions with larger sectors. Particularly useful is a set of programs that let you back up, restore, and verify directories. Corel saves all backups to single files on the optical drive. This is more efficient than using a series of small files, given the large cluster size.

The Corel 800 installs easily on the Macintosh as well. As with most Macintosh peripherals, you connect it to the Mac with a standard 25-pin-to-50-pin SCSI adapter. The required SCSI terminators are built into the drive itself, and the SCSI bus design lets you connect up to six external devices to the Mac's connector, as long as the devices have the two connectors required for daisy chaining peripherals. The Corel 800 has only one connector. If you plan to use the Corel drive in conjunction with other SCSI devices, plan on placing the Corel at the very end of the daisy chain.

On the Macintosh, the WORM Tools utility provides the commands you need to reactivate the history markers. It gives you a list of all the markers by date, but it lacks the convenient list-by-file functions of the PC software.

Using the standard Mac interface, you simply select a point in time, and the software restores the disk to its earlier status. Your drive will reappear on the Mac Desktop in a write-protected state. You then copy the files you need back onto your hard disk and deactivate the history marker. Tools also gives you functions to set various operating parameters in the device driver.

Other software provided with the Corel Mac package includes WORM Format, the formatter and partition program;

continued

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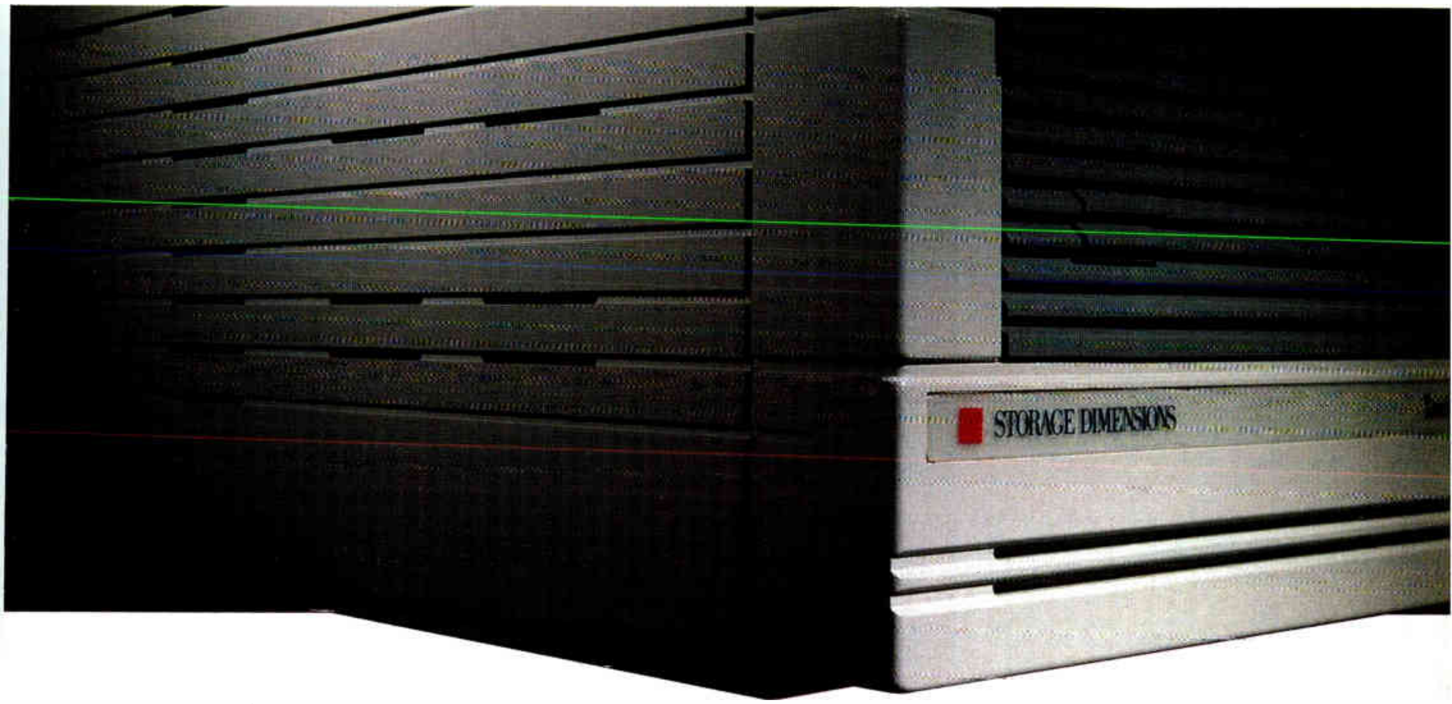

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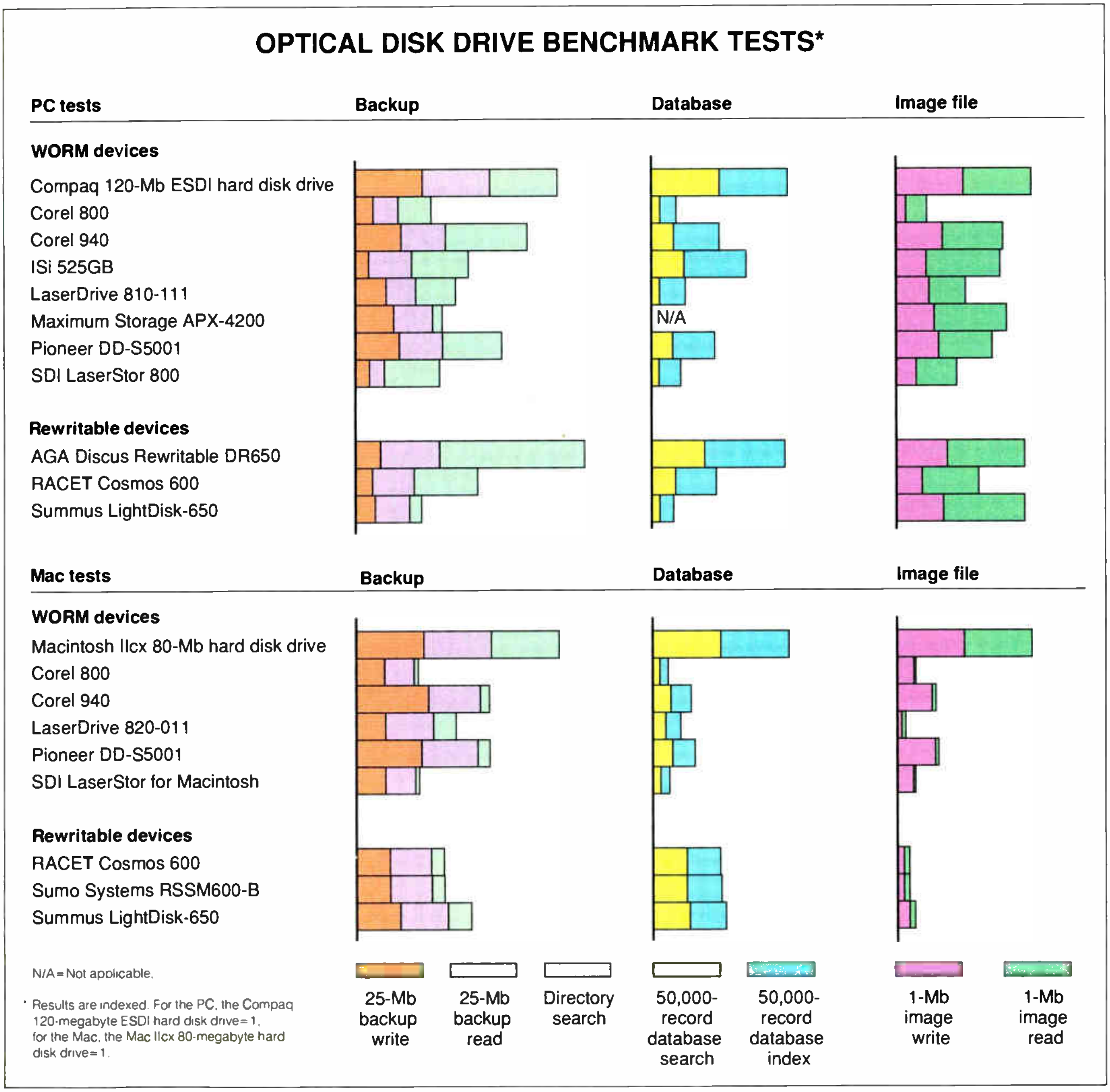

Graphs show each drive's relative performance in a suite of typical optical disk applications. We ran all tests on a Compaq Deskpro 386 and a Macintosh IIcx. For ease of comparison, we indexed our PC platform results to the Compaq's 120-megabyte ESDI hard disk drive, and the Macintosh platform results to the Mac IIcx's 80-megabyte internal hard disk drive. We stacked the results to conserve space; they do not represent a meaningful cumulative result. Shorter segments show better performance. The Corel 940 and the Pioneer WORM drives were consistently fast, while, among erasable drives, those from AGA and Summus split the PC and Macintosh environments.

WORM Diagnostics, for checking the operation of the WORM drive; and an INIT for the Mac's System Folder.

Corel 940

The Corel 940 is a 940-megabyte Panasonic WORM bundled with a Corel interface kit. Both the PC and Macintosh subsystems sell for $3695. The Corel 940's modified CAV format allows the drive to pack data at a high density without sacrificing speed. (For an explanation of CAV, CAD, and CLV formats, see the text box "Optical Technologies.")

While the software description for the Corel 800 is entirely applicable to the Corel 940, the hardware makes for a sharp contrast in performance. The Corel 940, with far better seek-time ratings, easily outperformed the Corel 800. On the PC, in fact, the Corel 940 was often the fastest drive we tested.

This drive is also one of the fastest WORMs on the Macintosh. We liked the external SCSI selection switch on the back panel and the daisy-chainable dual

continued

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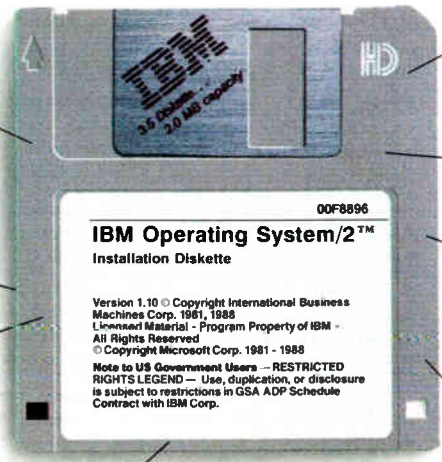

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Optical Technologies

Ask several vendors how optical disk technology works, and you're likely to get several different answers. In addition to variations in disk format, vendors use a variety of media types, recording techniques, and rotation schemes, each of which has its own unique advantages and disadvantages. Here, in a nutshell, are the basic technologies used in WORM (write once, read many times) drives and rewritable optical disk systems.

WORM drives are made up of a layer of recording material sandwiched between two plastic plates. The double-sided disk requires two recording layers. WORMs in this review use one of two recording materials: tellurium alloy or dye-polymer. These have excellent life expectancies of from 10 to 15 years, but WORM media technology is too new to have proven its durability in real-world use. Tellurium alloy is by far the most common recording material; six of the nine WORM drives we tested use it. Dye-polymer, used in the units from Pioneer and Storage Dimensions, Inc. (SDI), is cheaper to manufacture than tellurium-based products, and projected lifetimes are slightly better.

All the WORMs we tested except the Corel 940 use a recording technology known as *ablative pit*. They record by focusing a high-powered laser through the plastic layer to burn a hole in the recording material. The presence or absence of these burned pits represents data bits. To read back the data, the same laser shines a low-power beam on the media, and a photosensor detects reflectivity changes between the pits and the untouched surface. This rather complex process requires an expensive and heavy head assembly, and these drives provide only one head each; to access different sides of the disk, you must remove the cartridge, flip it over, and reinsert it.

The Corel 940 WORM uses a similar technique, but instead of burning a hole, the drive laser modifies the structure of the recording medium so that it changes the phase of reflected light. The drive detects phase changes in light from the read laser reflected off the disk surface.

While several companies are exploring different erasable optical technologies, magneto-optical is the only one currently refined enough for use in commercial products. Like WORM disks, magneto-optical disks consist of a layer of recording material sandwiched between two plastic disks. The magnetic recording material of an unused disk has a uniform magnetic orientation. At room temperature, the material is insensitive to normal magnetic fields, but at high temperatures (past its "Curie point") you can alter it magnetically.

To write on this material, the drive head heats the target area with a laser and applies a magnetic field to reverse the orientation of the target area. Once the material cools, it retains the reversed magnetic orientation; thus, the drives can represent data bits by varying magnetic orientations within the disk.

Erasing and rewriting data requires two passes. On the first pass, the head simply heats the target area and applies a uniform magnetic field to return the target area to its original orientation. The second pass writes the new data. The drive reads data by focusing a laser beam at the recording layer. The polarity of the reflected light changes according to the magnetic orientation of the disk (this is known as the *Kerr effect*). The drive detects reflected polarity and uses it to distinguish spaces from marks. Like WORM drives, magneto-optical drives can access only one disk side at a time.

Capacity vs. Speed

Optical drives use different rotation schemes and track organization to optimize access time or disk capacity. The two most common are constant angular velocity (CAV) and constant linear velocity (CLV). Like magnetic drives, CAV devices maintain a constant rotational speed. Since the data rate at the head is always constant, all tracks must contain the same amount of information. Although the outer tracks are longer, they can contain only as much data as the shortest (innermost) track. As a result, CAV disks waste potential disk capacity.

CLV drives maximize capacity, but they're more complex and generally slower than those using CAV. They vary the rotational speed of the disk to maintain constant velocity of the head over the disk, whether on an inner or an outer track. CLV drives, therefore, can pack the entire drive at the highest data density that the disk can support.

Corel's 940 and Information Storage, Inc.'s (ISi) WORM drives use two other methods, modified CAV and constant area density (CAD), respectively. Modified CAV, a CLV-CAV hybrid, involves splitting the disks into several concentric regions. Within each region, the disk spins at a constant rate; the rate increases for regions located nearer the outside of the disk. This method achieves high data density, and control is not as complex as when using CLV.

ISi's CAD drive is essentially CAV, but it puts an interesting spin on the technique by interleaving data tracks. The result is a honeycomb pattern of data bits with nearly the same data density on outer and inner tracks. For the user, this means very high capacity combined with good performance.

In addition to different rotation methods, optical drives use different methods for organizing tracks. Only ISi, Maximum Storage, and the Corel 940 use the concentric tracks familiar to magnetic disk users. This scheme results in relatively short seek times but suffers when the drive must transfer large amounts of information (i.e., when there are multiple tracks). The rest of the manufacturers chose a spiral track organization, where all data is arranged in a long continuous groove, as on a phonograph record. While this method is more efficient for sustained transfer, it's also slower at finding a randomly selected sector.

SCSI connectors. Most of the WORM drives that we tested automatically ejected the cartridge when we dragged the drive's icon into the trash. The Corel 940 has a manual cartridge eject.

The Macintosh software is standard Corel fare—formatting, diagnostics, and version-retrieval functions, as with the Corel 800. It's an excellent choice, especially if you want more storage.

ISi 525GB

At 640 megabytes per side, Information Storage, Inc.'s (ISi) 525GB was the largest-capacity drive for the PC that we tested. For $6288, the system includes a drive, a Western Digital SCSI controller card, and software. The unit also includes dual SCSI connectors for daisy chaining.

continued

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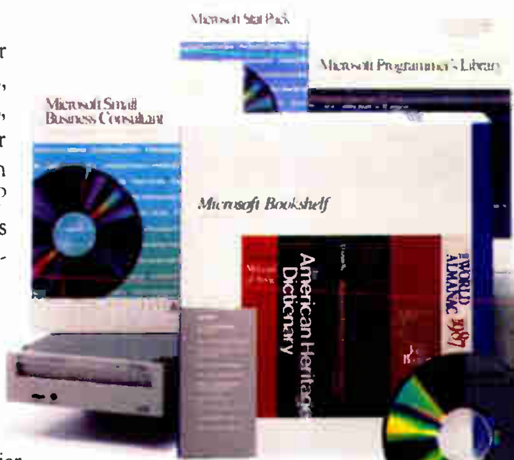

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ISi's unique CAD format gives the unit a good access-time rating and respectable performance, especially considering its high capacity. The drive performed well on our benchmarks, often finishing at or near the top of the list.

The drive uses the DOS file system and simply looks like a logical block device to DOS. It maintains block-update information on disk, so you won't lose any data in a sudden blackout. All DOS disk-function calls worked smoothly.

ISi's WORM-TOS PLUS software includes a DOS patch (for larger sectors and partitions), a partition editor, and Back Track version utilities. The driver and patching software allow for up to 640-megabyte partitions. The Back Track utility suffers from a clumsy user interface but was able to recover older file versions without problems.

Overall, the 525GB is an excellent drive. It's fast and fully DOS-compatible, and it has outstanding capacity. Unfortunately, both the drive and media are relatively expensive.

LaserDrive 810-111

LaserDrive sells two nearly identical WORM drives, the 810-111 for DOS machines ($5495) and the 820-011 for the Macintosh (see below). The LaserDrive 810-111 media offers 405 megabytes per side, with interface cards available for both PC and Micro Channel machines. A second SCSI connector and external-device-select thumbwheel allow you to daisy chain other SCSI devices off the LaserDrive.

The LaserDrive was the largest drive we tested. It stands about 15 inches tall. While most of the test units were designed for desktop use, the LaserDrive can stand comfortably on the floor, freeing up valuable desk space.

The 810-111 had the worst access-time specification of the units we tested. But the system as a whole outperformed several drives with better ratings, turning in a moderate performance overall.

The drive uses the DOS file system and acts like a standard device driver disk. It emulates random-access writes by keeping logical address markers with each sector on the disk. The drive keeps a logical history in a reserved area on disk to keep track of current versions. It executed all the DOS test functions perfectly.

Installing both the hardware and software components was simple, and we had no trouble operating the drive. The driver makes it possible to have disk partitions as large as one disk side. Other software for the LaserDrive 810-111 is quite sparse; there are diagnostic and format utilities, but there is no provision for retrieving outdated versions.

LaserDrive 820-011

The $5995 LaserDrive 820-011 for the Mac includes driver/utility software and a cable, and it uses the same cartridges and drive as the LaserDrive 810-111.

In our benchmark tests, the Laserdrive 820-011 did well on the backup read test, behind the Corel 940, the Pioneer DD-S5001, and the rewritable Summus LightDisk. But the LaserDrive's poor performance on the 1-megabyte image retrieval tests suggests that it's best used for backups or for storing large files.

ISi's unique CAD format gives the unit a good access-time rating.

The Mac OS has some difficulty calculating the actual amount of remaining space because of rewritten sectors. The utility software provided with the drive includes a desk accessory that displays the amount of rewritable space remaining on the drive. Formatting cartridges is simple: You just click on INITIALIZE in response to the standard Macintosh "This disk is unreadable" alert box.

Maximum Storage APX-4200

The Maximum Storage drive for the PC ($4450) is unique for two reasons. First, it uses an ESDI host adapter, so daisy chaining drives is out of the question. Second, and more important, its software approaches DOS compatibility from a radically different angle.

Unlike most other programs, which use the DOS file system, the APX-4200's MAXSYS software creates its own file system that's more appropriate for the drive's write-once capabilities. It traps all INT 21H calls, filters out those intended for the optical drive, and passes the remaining commands through to the standard INT 21H handler.

This high-level DOS interface makes for the slickest version-retrieval software of any of the WORMs that we tested. MAXSYS extends the standard MS-DOS naming convention from FILENAME.EXT to FILENAME.EXT#VN, where VN is the version number. By default, MAXSYS assumes the latest version, but you can specify any earlier one by simply putting the number at the end. This means that for functions that use ASCIIZ strings, you can explicitly specify the version number when you're calling the function. This won't work with DOS's COPY command, however, so Maximum Storage provides a COPY replacement. Other version utilities include LNK, which can effectively retrieve an old version of a file by linking it with a new directory entry, and XDIR, an expanded replacement for DIR that can handle version information.

Unfortunately, this software scheme also results in relatively poor DOS compatibility. The file system doesn't support hidden, system, or archive attributes, and our attempts to open a file by using a file control block failed. The APX-4200 was also unable to run our large database tests; Maximum Storage representatives confirmed the problem and are working on a solution.

The drive turned in excellent times on most of our other benchmarks, but it was slow on directory searches.

Pioneer DD-S5001

Pioneer Communications' DD-S5001 system includes a Pioneer WORM drive and a Corel interface kit for either PC compatibles ($3895) or Macintosh ($3695) computers. If you're working with DEC, Sun, or other machines or operating systems, contact Pioneer; several interfaces are available from third parties.

At 327 megabytes per side, the Pioneer drive has the lowest capacity of the WORMs we reviewed. But it's also the least expensive, and its media cost per megabyte is quite low.

The DD-S5001 performed exceptionally well in our benchmark tests. On the PC side, it earned the top composite score on the backup test, and it was near the top on both the database and image suites. It was fully DOS-compatible.

Difficult access to the SCSI switches inside the unit made installing the DD-S5001 on the Macintosh a cumbersome process. Fortunately, most people will need to set these switches only once. The cable attaches to standard SCSI connectors, and the unit includes two connectors for daisy chaining or connecting an external terminator.

Capacity and installation are only part of the story. The DD-S5001 is a fast WORM drive, and it consistently kept

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COMPANY INFORMATION

Advanced Graphic Applications, Inc.
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90 Fifth Ave.
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(212) 337-4200
Inquiry 1071.

Corel Systems Corp.
(Corel 800, Corel 940)
1600 Carling Ave., Suite 190
Ottawa, Ontario, Canada K1Z714
(613) 728-8200
Inquiry 1072.

Information Storage, Inc.
(ISi 525GB)
2768 Janitell Rd.
Colorado Springs, CO 80906
(719) 579-0460
Inquiry 1073.

LaserDrive Ltd.
(LaserDrive 810-111,
LaserDrive 820-011)
1101 Space Park Dr.
Santa Clara, CA 95054
(408) 970-3600
Inquiry 1074.

Maximum Storage, Inc.
(Maximum Storage APX-4200)
5025 Centennial Blvd.
Colorado Springs, CO 80919
(719) 531-6888
Inquiry 1075.

Pioneer Communications of America, Inc.
(Pioneer DD-S5001)
Optical Memory Products Division
Sherbrooke Plaza
600 East Crescent Ave.
Upper Saddle River, NJ 07458
(201) 327-6400
Inquiry 1076.

RACET Computers Ltd.
(RACET Cosmos 600)
3150 East Birch St.
Brea, CA 92621
(714) 579-1725
Inquiry 1077.

Storage Dimensions, Inc.
(SDI LaserStor for Macintosh,
SDI LaserStor 800)
2145 Hamilton Ave.
San Jose, CA 95125
(408) 879-0300
Inquiry 1078.

Sumo Systems
(Sumo Systems RSSM600-B)
1580 Old Oakland Rd.,
Suite C103
San Jose, CA 95131
(408) 453-5744
Inquiry 1079.

Summus Computer Systems
(Summus LightDisk-650)
17171 Park Row, Suite 300
Houston, TX 77084
(713) 492-6611
Inquiry 1080.

pace with the speedy Corel 940. The Corel software package provided with the drive handled the utility and driver functions.

Along with Corel's 940, this drive clearly proves that expensive is not always better.

SDI LaserStor for Macintosh

LaserStor for Macintosh, from Storage Dimensions, Inc. (SDI), sports dual SCSI connectors and internal SCSI address selection switches. For $4999, you get the drive system, cabling, and driver/utility software.

It's no coincidence that the LaserStor and the Corel 800 displayed almost identical performance—both use Ricoh disk subsystems and Corel software. The vertically mounted LaserStor takes up less desk space than many other drives. It installed easily and worked without any surprises.

SDI LaserStor 800

The LaserStor 800 PC-based WORM takes an unusual approach to solving the problems of slow access times and inefficient disk use: It caches both data and directories on the system's hard disk drive. The optical drive itself is the same unit that SDI's Macintosh WORM uses; the company plans to port the caching scheme to the Macintosh disk drive, but the software is currently available for the DOS environment only. As with the Pioneer drive, other operating-system support is available from third parties. For $4495, the PC system gives you the drive, cable, interface card, software, and a comprehensive combination user's and programmer's guide.

SDI's LaserCache software maintains logical-to-physical-sector translation tables and communicates with DOS at the device driver level, as do most other WORMs. Our tests showed it to be completely DOS-compatible. LaserCache, however, keeps translation tables and data in a reserved caching area on the magnetic disk. It reads the translation tables from the WORM only once, when the cartridge is mounted; from that point, it makes all updates to the cache. The unit also caches both data reads and writes and flushes the cache only as it approaches capacity. Before removing a cartridge, the user must flush both data and index information from the cache.

In addition to the advantage of greater speed, the cache also uses the WORM more efficiently than does a direct-write scheme. Rewritten translation tables and user data often waste a great deal of space on a WORM, where any written data consumes space. With LaserCache, rewritten information replaces old information in the magnetic cache, and permanent writes happen only when the cache is flushed.

We tested the unit with an 11-megabyte hard disk cache. The system has no defaults, but you must set aside at least 1 megabyte for caching space. Overall performance was disappointing, especially when you consider the several minutes it took to flush the cache after we finished the tests.

The caching software also makes it more difficult to retrieve older file versions. If you need to save a file and guarantee its recoverability, you must flush the cache after you save the file. If you're running a scanning or CAD application, for example, this means you must save the file, exit the application, run the cache flush utility, and reenter the application. Once you've done that, you can recall the file using LaserCache utilities.

The Rewritables

Rewritable optical drives are very new. Only two vendors, Sony and Ricoh, manufacture the drive mechanisms used in the systems we reviewed. But don't let the underlying similarities fool you. Software and interface components can make for significant differences.

AGA Discus Rewritable DR650

Among the erasable optical units we reviewed, the champion is AGA's DR650. Its high capacity, trouble-free operation, and blinding speed make it ideal for AT or PS/2 users with large storage requirements. The system runs on a standard

continued

SCSI bus, and you can chain any SCSI device off the drive. Unfortunately, a Mac version of this product wasn't released in time for this review.

At $6495, the DR650 isn't cheap, but it proved to be the best drive to use with DOS. It consistently turned in top performances, matched only by the Summus drive on the image tests. Although the device driver lets you configure a system RAM cache, we ran it in the default configuration without caching enabled. Adding the cache should further enhance performance.

The only difference in capacity between this drive and the other magneto-optical units is in the data cartridge. All four of the units we tested can use both 325-megabyte-per-side cartridges and the 297-megabyte-per-side variety. But while they can use the same physical media, proprietary formats mean you can't swap cartridges between different drives to share data.

The higher-capacity cartridge has 1024 bytes per sector and less overhead than the lower-capacity, 512-byte-per-sector disk. The current version of the ISO standard for magneto-optical media covers both 512- and 1024-byte sectors. AGA has chosen to sell and support 325-megabyte, 1024-byte-per-sector cartridges. Because the cluster size is so much larger, these cartridges will cost you more in data overhead if you store small files.

AGA's software includes the driver, format and partitioning utilities, and a DOS patch to enable large partitions. It ran all our tests and executed all DOS disk function calls without a hitch.

RACET Cosmos 600

RACET's Cosmos 600, based on Ricoh's 600-megabyte magneto-optical drive, is available for both PC and Macintosh platforms. It's the most network-oriented erasable unit we reviewed, with support for TOPS, AppleShare, and Novell's NetWare. The PC system sells for $5645; the Macintosh version costs $5590.

On our DOS test machine, the AGA unit consistently outperformed the RACET drive. But the Cosmos 600 was by no means slow; it bested the Summus system on two of the tests.

RACET's drive was completely compatible with DOS. The PCMS software that comes with the drive is adapted from programs shipped with RACET's tape drives. Utilities include formatting, partitioning, and diagnostic programs. PCMS also lets you assign passwords to partitions.

An external SCSI device-select switch made Mac installation easier. Dual SCSI connectors let you connect the external terminator or another daisy-chained peripheral. Performance was solid—better than the Mac's internal hard disk drive on both the FoxBASE and MPW tests.

RACET's PCMS utility software works reliably, but it can be dangerous: It almost wiped out our hard disk drive. Most of the utilities search through the SCSI bus and bring up a screen with a list of the devices it finds. During the last phase of testing, we inadvertently selected device 0 (the Mac's internal hard disk drive) instead of device 1 (the RACET drive). PCMS happily stomped the Macintosh driver on the hard disk and destroyed the partition table.

Among the erasable optical units, the champion is AGA's DR650.

Sumo Systems RSSM600-B

The Sumo RSSM600-B uses the same internal subsystem as the Cosmos 600 and performed almost identically on all the tests. We tested the unit on the Macintosh, but Sumo began shipping a PC version as we went to press. Two SCSI connectors and an external SCSI address switch grace the back panel. Physically, the Sumo drive is the largest of the rewritables. It's approximately square and sized to fit beautifully under a classic Mac SE or Plus footprint.

Perhaps the Sumo's best feature is its price: $4500 for the Mac drive ($4700 for the PC) and $260 per 600-megabyte (double-sided) cartridge makes it the cheapest of the rewritables.

Summus LightDisk-650

Like the AGA system, Summus's LightDisk-650 incorporates Sony's magneto-optical drive. Unfortunately, Summus's system can't touch the AGA when it comes to performance. What Summus has going for it is a standard SCSI connection and software that lets it fit comfortably with just about any system. The drive is available for an impressive lineup of machines and a host of operating systems (see table 1); PC kits sell for $6495, and Macintosh kits sell for $5495. Installing the drive may require opening the case to get to the internal SCSI address switches.

The Summus drive for the PC doesn't come with any utility software. In fact, it doesn't come with any software at all. The driver card has a BIOS extension ROM that lets it recognize the LightDisk at boot time. You use a utility provided in the ROM to do a low-level format, and standard DOS FDISK and FORMAT commands for formatting and partitioning. All the DOS drive functions we tried worked correctly.

Although the Macintosh rewritables were close in terms of performance, the LightDisk edged out its two Ricoh-based competitors, RACET and Sumo.

The Disk Director 3.0 software (provided with the Macintosh version) handles the low-level formatting and partitioning. The LightDisk is unique in that the partitioning lets you split up the 297 megabytes into several partitions and have them all come up as different logical disk drives.

Buy or Wait?

Optical storage is a young technology, and compatibilities and specifications change rapidly; if you have an application in mind, call the vendor. If you're looking to an erasable optical drive as a medium for data distribution, you may do well to hold off on any purchase until these drives conform to a standard.

On the IBM PC–compatible side, several drives stand out. The ISi 525GB is fast and has an enormous capacity, but it's also quite expensive. The Maximum Storage APX-4200 has the best version-control software and performs respectably, but it has problems simulating random-access writes.

Our favorite WORM drives in both the DOS and Macintosh environments are the Corel 940 and the Pioneer DD-S5001. Both drives are excellent performers in all applications, and both are outstanding values.

The AGA Discus Rewritable DR650 is the obvious choice if you need a rewritable drive for DOS, but all four magneto-optical drives have strong points: the RACET Cosmos 600 has strong networking support, the Sumo RSSM600-B is relatively inexpensive, and the Summus LightDisk-650 delivers the best performance on the Macintosh. ■

Steve Apiki and Howard Eglowstein are testing editors for the BYTE Lab. You can reach them on BIX as "apiki" and "heglowstein," respectively.

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- Desktop case with Turbo and Power LED Display, keyboard lock, hardware and Turbo switch.
- Norton SI Rating V4.0: 15.3.
- Industry standard Phoenix compatible BIOS.
- One and Zero Wait State operations.
- Clock/Calendar with Battery Back-up.
- Monitor not included in above price.

Also available in small footprint and Tower case.

See chart for Video and Hard Drive Options.

ACCESS 286/20

- 16-bit 80286 Main System Board.
- Dual 10/20 MHz switchable CPU speed.
- 1MB RAM, expands to 5MB on motherboard.
- Eight slots: (6-16 bit, 2-8 bit).
- Supports 80287 Math Coprocessor.
- One parallel, serial and game port.
- 102-key "AT" style enhanced keyboard.
- 1.2MB Hi-density 5.25" floppy disk drive.
- Five ½ height drive bays.
- Western Digital 2:1 interleave controller.
- 220 watt high capacity power supply.
- Desktop case with Turbo and Power LED Display, keyboard lock, hardware and Turbo switch.
- Norton SI Rating V4.0: 22.5.
- Industry standard Phoenix compatible BIOS.
- One and Zero Wait State operation.
- Clock/Calendar with Battery Back-up.
- Monitor not included in above price.

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See chart for Video and Hard Drive Options.

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VGA	$999.00	$1199.00	$1799.00

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ACCESS 286/25

- 16-bit 80286 Main System Board.
- Dual 10/25 MHz switchable CPU speed.
- 1MB RAM, expands to 5MB on motherboard.
- Eight slots:(6-16 bit, 2-8 bit).
- Supports 80287 Math Coprocessor.
- One parallel, serial and game port.
- 102-key "AT" style enhanced keyboard.
- 1.2MB Hi-density 5.25" floppy disk drive.
- Five ½ height drive bays.
- Western Digital 2:1 interleave controller.
- 220 watt high capacity power supply.
- Desktop case with Turbo and Power LED Display, keyboard lock, hardware and Turbo switch.
- Norton SI Rating V4.0: 31.6.
- Industry standard Phoenix compatible BIOS.
- One and Zero Wait State operations.
- Clock/Calendar with Battery Back-up.
- Monitor not included in above price.

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See chart for Video and Hard Drive Options.

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- Supports 8087-10 Math Coprocessor.
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- 102-key "AT" style enhanced keyboard.
- 360KB 5.25" floppy disk drive.
- Four ½ height drive bays.
- Dual floppy controller, supports 720K format.
- 150 watt high capacity power supply.
- Desktop case with Turbo and Power LED Display, keyboard lock, hardware and Turbo switch.
- IBM XT compatible EROS BIOS.
- Clock/Calendar with Battery Back-up.
- Monitor not included.

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See chart below for Video and Hard Drive Options for *ACCESS* Turbo XT/10

	1 Floppy	20MB-65m	40MB-28ms
Mono	$139.00	$409.00	$589.00
CGA	$339.00	$599.00	$779.00
EGA	$499.00	$769.00	$959.00

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In addition to operating as a stand alone computer system, the ***ACCESS*** Turbo XT/10 is an ideal solution for your multi-user applications. The ***ACCESS*** Turbo can be configured as a Workstation on the Novell, 3Com, Unix and Xenix environments. Call TOLL FREE **800-233-8950** and talk with our trained and authorized sales and support staff. Look at our Networking section for a sample of products offered in the Novell Networking Arena.

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- System memory expandable to 9MB.
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- 8MHz bus clock, wait state selectable.
- Supports 80387 Math Coprocessor.
- One parallel port and two serial ports.
- 102-key "AT" style enhanced keyboard.
- 1.2MB Hi-density 5.25" floppy disk drive.
- Five ½ height drive bays.
- Western Digital 1:1 interleave controller.
- 200 watt high capacity power supply.
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- COMPAQ compatible, 32% faster than COMPAQ 386.
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- Norton SI Rating V4.0: 22.5.
- 64K Bios, setup and diagnostic utility built-in.
- Zero Wait State Operation.
- Clock/Calendar with Battery Back-up.
- Monitor not included.

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See chart for Video and Hard Drive Options For *ACCESS* 386/20 Tower

	40MB-28ms	159MB-23ms	338MB-18ms
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EGA	$899.00	$1699.00	$2199.00
VGA	$999.00	$1799.00	$2299.00

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ELS Level-II V2.15 . . . . $1,099.00
Advanced NETWARE 286 V2.1 . . . $1,995.00
SFT NETWARE 286 V2.15 . . . . $3,095.00

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ARCNET (8-bit) PC/XT $129.00
ARCNET (16-bit) 286/386 . . . . $299.00
ARCNET MCA PS/2 . . . . $299.00
Active Hub $299.00
ETHERNET (8-bit) PC/XT $239.00
ETHERNET (16-bit) 286/386 . . . . $289.00
ETHERNET MCA PS/2 . . . . $359.00
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One parallel, serial, and game port.

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Collegian Software.
PFs: First Choice.

$979

THE ACCOUNTANT

***ACCESS* 286/12MHz Computer.**
512K RAM installed on the Motherboard.
40MB Hard Disk Drive w/controller.
1.2MB 5.25" floppy disk drive.
102-key "AT" style enhanced keyboard.

Espon FX-1050 Printer.
264cps 136 column dot matrix.

Accountant Monitor.
Monochrome TTL display and adapter.
12" diagonal screen display.

Accountant Software.
Lotus 1-2-3

$2199

THE SECRETARY

***ACCESS* Turbo XT/10 8088 Computer.**
512K RAM installed on the Motherboard.
20MB Hard Disk Drive w/controller.
360K 5.25" floppy disk drive.
102-key "AT" style enhanced keyboard.

Brother HR-20
Daisywheel 20cps print speed.

Secretary Monitor
Monochrome TTL display and adapter.
12" diagonal screen display.

Secretary Software.
PFS: Write

$1299

THE PUBLISHER

***ACCESS* 386/16MHz Computer.**
1MB RAM installed on the Motherboard.
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1.2MB 5.25" floppy disk drive.
102-key "AT" style enhanced keyboard.

Hewlett-Packard LaserJet II
8 Page per minute.

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Publisher Software
PFS: First Publisher

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Our smaller version, the 386MT, features 12 slots, five half-height drives, and a 200 watt power supply. Both MaxSys systems allow you to upgrade your original hardware and software investments to meet the standards of today... and tomorrow. They're 100% IBM™ compatible and have an Adv Norton 4.0 SI rating of 40.0 — the highest for AT™ systems. Application options range from an ultra high-end personal computer to networked file/compute/print servers supporting diskless work-stations and ASCII terminals. Plus, the MaxSys systems run MS DOS™, Ethernet™, ARCnet™, Cheapernet, Helios™, Novell™, UNIX™/XENIX™, 3 Com™, Token Ring, OS/2™, or POSIX.

Both MaxSys systems are available in a variety of configurations and include full technical support, complete documentation, and a one year warranty.

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	Norton 4.0 SI	Expansion Slots	Drive Capacity
CSS MaxSys	40.0	12	10 H/H
IBM Model 80	30.5	8	4 H/H
Compaq 386/25	30.5	8	4 H/H

Compared to IBM and Compaq the MaxSys 386T comes out on top.

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Circle 75 on Reader Service Card (DEALERS: 76)

MCA Meets SX

New machines from IBM and American Mitac pair the 80386SX with IBM's Micro Channel architecture

Mark L. Van Name
and Bill Catchings

The IBM PS/2 Model 55 SX and the American Mitac MPS2386 differ in price, expandability, and compatibility.

The marketplace is still undecided about the 80386SX microprocessor and IBM's Micro Channel architecture (MCA), but that hasn't stopped two companies from introducing machines that incorporate both. The IBM PS/2 Model 55 SX and the American Mitac MPS2386 combine these two technologies in very different packages.

The mixture is in some ways an odd one. The 80386SX's main goal is to let you run 80386-specific software for little more than the cost of an 80286-based system. The MCA, on the other hand, boasts better performance, particularly for 32-bit peripherals, but at a higher cost.

The Model 55 SX base unit comes in two configurations: with a 30-megabyte hard disk drive ($3895), and with a 60-megabyte hard disk drive ($4295). The only standard software is the IBM Reference Diskette, which you use to tell the MCA bus about new peripherals. Our evaluation system had the 60-megabyte drive and came with an additional 2 megabytes of memory, an IBM 8513 VGA color monitor, and MS-DOS 3.3, for a total list price of $6560. (Although the machine didn't come with a math coprocessor, we added one before running the benchmarks.)

The standard American Mitac MPS2386 sells for $2695. It includes more standard software than the Model 55 SX: MS-DOS and GWBASIC 4.0, the Phoenix Reference Diskette for MCA configuration, and an expanded memory emulator. Two 3½-inch hard disk drives are optional for the MPS2386: a $650 40-megabyte drive and a $1500 100-megabyte drive.

Our 40-megabyte evaluation system included a Mitac VGA monitor (Tatung is the OEM), a 16-MHz 80387SX (which Mitac does not sell), a total of 4 megabytes of memory, and a 1.2-megabyte 5¼-inch floppy disk drive. We tested the machine running DOS 3.3; however, Mitac now offers only version 4.0.

With these extras (assuming $650 for the 80387SX), our evaluation unit would cost $5879. That puts it at almost $700 less than the IBM unit, without the 5¼-inch floppy disk drive and 80387SX included in the Mitac unit. Toss out those two items and the price is $5114, or over $1400 less than the Model 55 SX. Clearly, price is a major reason to consider the MPS2386.

Architecture

Because both these machines use the 80386SX rather than its speedier cousin, IBM and Mitac were able to skimp a bit on their memory architectures. In particular, neither system uses a cache. The MPS2386 relies instead on a combination of two-way interleaving and paging

continued

IBM PS/2 Model 55 SX

Company
IBM Corp.
1133 Westchester Ave.
White Plains, NY 10604
(800) 426-2468

Components
Processor: 16-MHz Intel 80386SX
Memory: 2 megabytes of 85-ns DRAM in a 2-megabyte SIMM, expandable to 4 megabytes on the motherboard; 128K bytes of BIOS ROM
Mass storage: 1.44-megabyte 3½-inch floppy disk drive; 30-megabyte hard disk drive (Model 8555-031) or 60-megabyte hard disk drive (Model 8555-061)
Display: IBM 8513 VGA monitor; VGA circuitry; 256K bytes of display memory; DB-15 monitor connector on the motherboard
Keyboard: 101-key IBM Enhanced
I/O interfaces: RS-232C serial port with DB-25 connector; DB-25 parallel port; PS/2-style keyboard connector and mouse connector; three 16-bit MCA slots, one with IBM video adapter extension

Size
16 × 4 × 15½ inches; 19 pounds

Price
Base system: $3895
System as reviewed: $6560

Inquiry 854.

American Mitac MPS2386

Company
American Mitac Corp.
410 East Plumeria Dr.
San Jose, CA 95134
(408) 432-1160

Components
Processor: 16-MHz Intel 80386SX
Memory: One megabyte of 100-ns DRAM in four 256K-byte SIPs, expandable to 8 megabytes on the motherboard; 128K bytes of BIOS ROM
Mass storage: 1.44-megabyte 3½-inch floppy disk drive; ST-506 hard disk drive controller card; 40-megabyte or 100-megabyte hard disk drive
Display: Mitac VGA monitor; VGA circuitry; 256K bytes of display memory; DB-15 monitor connector on the motherboard
Keyboard: Modified 101-key IBM Enhanced
I/O interfaces: RS-232C port with DB-25 connector; DB-25 parallel port; PS/2-style keyboard connector and mouse connector; six 16-bit MCA slots, one with IBM-compatible video adapter extension

Size
14½ × 6¼ × 16½ inches; 28 pounds

Price
Base system: $2695
System as reviewed: $5879

Inquiry 855.

(with 2K-byte pages) to let it run without wait states most of the time with its 100-nanosecond DRAM. The Model 55 SX also uses paging (with 2K-byte pages), but it lacks the MPS2386's interleaving. Not surprisingly, this architecture makes the IBM unit slower, even though it uses faster 85-ns DRAM.

The MPS2386's DRAM comes on either 256K-byte or 1-megabyte single in-line packages. You install these SIPs in matched sets of four into the eight SIP slots, so the unit's memory can total 1, 2, 4, 5, or 8 megabytes. The base system uses four 256K-byte SIPs to make 1 megabyte.

The Model 55 SX has far fewer memory options. Its two single in-line memory module slots can hold either 1- or 2-megabyte SIMMs. The base models include one 2-megabyte SIMM; you can have configurations with 2, 3, or 4 megabytes.

Performance

The MPS2386's better memory architecture makes it about 15 percent faster than the Model 55 SX on BYTE's CPU index and 10 percent faster on the FPU index. The Model 55 SX wins the video index handily, however. Its index of 2.42 bests the MPS2386's mark of 1.57.

The disk I/O performances of the two machines are nearly the same. Other drives, however, would probably yield far different results, since Mitac's 100-megabyte drive is faster than the 40-megabyte unit we tested. IBM, however, doesn't offer a larger drive for the Model 55 SX, and its 30-megabyte drive is even slower than the 60-megabyte system that we tested.

In the critical application index, the two machines were too close to call. Both lost by nearly a 20 percent margin to Compaq's AT-bus 80386SX machine. On the positive side, both the MPS2386 and the Model 55 SX are about 20 percent faster than IBM's 80286-based Model 50 Z.

Compatibility

As we expected, the Model 55 SX worked with all the MCA boards we tried, including Computer Peripherals' Hook-Up PS2400 internal modem, Gateway Communications' G/Ethernet adapter, and Pixelworks' Ultra Clipper UM1280 graphics card (an interesting test because the board acts as a bus master). The Model 55 SX also had no trouble with Microsoft's Serial Mouse with driver version 6.11, nor with Xircom's Pocket Ethernet Adapter.

The MPS2386 didn't fare quite so well. It successfully ran all but the Gateway G/Ethernet board. We were unable to use that board with NetWare or Gateway's test programs. Because the board worked in the Model 55 SX, and because the MPS2386 ran NetWare over the Xircom Pocket Ethernet Adapter, we concluded that the MPS2386 had a problem with its MCA bus. A Mitac spokesperson said that the firm would investigate the problem and fix it in later production runs.

We also had a minor problem with the MPS2386's Reference Diskette program. On the surface, the MPS2386 seems to use the same Phoenix Reference Diskette (PRD) program as most MCA clones (including those from Tandy and ALR). As with the Model 55 SX, when you install a new board in the system, the machine tells you to run PRD. PRD then tells you that it can't find the .ADF file for that card.

Every MCA board comes with a floppy disk that contains configuration information for that board in a file with a name like 77F4.ADF. (The number identifies the board, while .ADF is the standard extension.) Because IBM's MCA machines use 3½-inch drives, these floppy disks are always 3½-inch.

Unfortunately, the MPS2386's PRD program checks drive B for the floppy disk with the .ADF file—but our evaluation unit's drive B was a 5¼-inch drive. We knew to copy the proper .ADF file to the PRD disk, but if you didn't know much about the PRD, you would be in trouble.

The Phoenix PRD program is also more complicated than IBM's. IBM's sacrifices some flexibility for its simplicity, but it never makes you figure out what to do; it just tells you what to do and then works like a charm.

Neither system had any software problems. Both systems flawlessly ran a wide range of applications, including Borland's Quattro 1.0, Reflex 1.14, SideKick Plus 1.00A, SuperKey 1.16A, Turbo C 2.0, and Turbo Pascal 4.0; Digitalk's Smalltalk/V 1.2; Kermit 2.32/A; MicroPro's WordStar 3.3 and 4.0; Lotus's

continued

IBM PS/2 Model 55 SX, Mitac MPS2386

APPLICATION-LEVEL PERFORMANCE

WORD PROCESSING	IBM	Mitac
XyWrite III + 3.52	**Med./Large**	**Med./Large**
Load (large)	:14	:14
Word count	:04/:28	:04/:30
Search/replace	:07/:28	:07/:28
End of document	:02/:16	:02/:16
Block move	:11/:10	:11/:11
Spelling check	:11/1:25	:12/1:27
Microsoft Word 4.0		
Forward delete	:19	:19
Aldus PageMaker 1.0a		
Load document	:11	:12
Change/bold	:35	:36
Align right	:28	:27
Cut 10 pages	:23	:23
Place graphic	:06	:04
Print to file	2:30	2:27
Index:	**2.07**	**2.08**

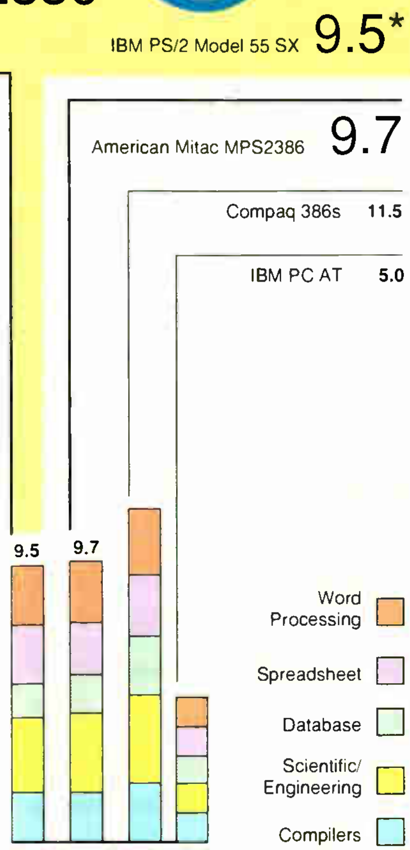
SPREADSHEET	IBM	Mitac
Lotus 1-2-3 2.01		
Block copy	:04	:05
Recalc	:02	:02
Load Monte Carlo	:29	:19
Recalc Monte Carlo	:07	:07
Load rlarge3	:07	:07
Recalc rlarge3	:01	:01
Recalc Goal-seek	:04	:05
Microsoft Excel 2.0		
Fill right	:07	:07
Undo fill	2:43	2:47
Recalc	:02	:03
Load rlarge3	:34	:32
Recalc rlarge3	:02	:02
Index:	**1.97**	**1.82**

DATABASE	IBM	Mitac
dBASE III + 1.1		
Copy	1:07	1:01
Index	:20	:20
List	1:47	1:40
Append	2:28	2:07
Delete	:04	:03
Pack	2:06	1:35
Count	:17	:17
Sort	1:25	1:21
Index:	**1.21**	**1.36**

SCIENTIFIC/ENGINEERING	IBM	Mitac
AutoCAD 2.52		
Load SoftWest	1:05	1:03
Regen SoftWest	:49	:48
Load StPauls	:14	:13
Regen StPauls	:08	:08
Hide/redraw	16:40	16:53
STATA 1.5		
Graphics	:39	:28
ANOVA	:17	:16
MathCAD 2.0		
IFS 800 pts.	:21	:21
FFT/IFFT 1024 pts.	:22	:21
Index:	**2.61**	**2.76**

COMPILERS	IBM	Mitac
Microsoft C 5.0		
XLisp compile	5:21	5:28
Turbo Pascal 4.0		
Pascal S compile	:07	:07
Index:	**1.67**	**1.67**

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT = 1.



*Cumulative application index. Graphs are based on indexes at left and show relative performance.

LOW-LEVEL PERFORMANCE[1]

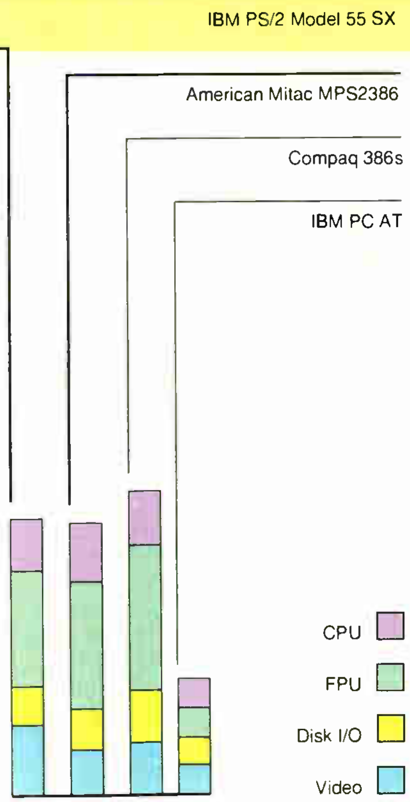
CPU	IBM	Mitac
Matrix	7.08	7.36
String Move		
Byte-wide	52.93	38.46
Word-wide:		
Odd-bnd.	49.62	40.90
Even-bnd.	26.47	19.28
Doubleword-wide:		
Odd-bnd.	33.08	28.25
Even-bnd.	21.55	18.31
Sieve	37.42	34.98
Sort	31.99	33.85
Index:	**1.78**	**2.04**

FLOATING POINT	IBM	Mitac
Math	14.59	13.35
Error[2]		
Sine(*x*)	3.90	3.55
Error		
e^x	4.32	3.94
Error		
Index:	**4.02**	**4.41**

DISK I/O	IBM	Mitac
Hard Seek[3]		
Outer track	5.02	3.32
Inner track	4.96	3.33
Half platter	9.43	9.98
Full platter	10.00	13.31
Average	7.35	7.49
DOS Seek		
1-sector	14.91	17.51
32-sector	29.17	33.61
File I/O[4]		
Seek	0.23	0.16
Read	1.13	1.12
Write	1.13	1.00
1-megabyte		
Write	5.75	5.64
Read	5.10	5.49
Index:	**1.36**	**1.38**

VIDEO	IBM	Mitac
Text		
Mode 0	4.06	6.15
Mode 1	4.07	6.15
Mode 2	4.25	6.42
Mode 3	4.25	6.41
Mode 7	N/A	N/A
Graphics		
CGA:		
Mode 4	1.69	2.54
Mode 5	1.68	2.56
Mode 6	1.87	2.80
EGA:		
Mode 13	2.74	4.45
Mode 14	3.11	5.05
Mode 15	N/A	N/A
Mode 16	3.08	5.00
VGA:		
Mode 18	3.26	5.27
Mode 19	1.89	2.84
Hercules	N/A	3.81
Index:	**2.42**	**1.57**

CONVENTIONAL BENCHMARKS	IBM	Mitac
LINPACK	284.30	279.46
Livermore Loops[5] (MFLOPS)	0.09	0.10
Dhrystone (MS C 5.0) (Dhry./sec.)	3474	3612



N/A = Not applicable.

[1] All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.

[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks currently set to 100).

[4] Read and write times for File I/O are in seconds per 64K bytes.

[5] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June 1988 BYTE.

Symphony 2; Microsoft's PC Paintbrush 2.0, Windows/386 version 2.0, and Word 4.0; Norton Utilities 3.00; Novell's NetWare 2.15; and Symantec's Q&A 1.1.

Little Room to Grow

Neither of these systems gives you many mass storage options. The Model 55 SX offers only 30- and 60-megabyte hard disk drives and has only two drive bays. The drives are both anemic performers, with access times of 39 and 27 milliseconds, respectively. As for the two bays, one holds a Mitsubishi 1.44-megabyte 3½-inch floppy disk drive, and the other accommodates the hard disk drive. Even if there was more room for expansion, the skimpy 90-watt power supply probably wouldn't support another drive.

The MPS2386 gives you more initial capacity, with both 40- and 100-megabyte hard disk drive options. Those drives are also faster; a Mitac spokesperson said that future units will use NEC drives with access times of 28 and 19 ms, respectively. Our evaluation unit held a 40-megabyte Rodime drive with a 28-ms access time.

The MPS2386 also has more room to grow. You can buy an optional internal NEC 1.2-megabyte 5¼-inch floppy disk drive like the one in our evaluation unit. (The Model 55 SX has to use an external 5¼-inch drive.) Further, even with the 5¼-inch floppy disk drive installed, our system had one empty half-height 5¼-inch drive bay. Its 150-W power supply gives you enough power to support those additions.

The MPS2386 also offers six MCA expansion slots (one of which is occupied by the hard disk drive controller) to the Model 55 SX's three.

Cases and Innards

You get inside the MPS2386 as you would any AT clone: by undoing five screws on the rear of the case and sliding the cover forward. There's a lot of metal inside this unit, including a pair of support braces that run from the front to the back of the chassis.

The motherboard is 13½ inches square. Its many surface-mounted chips clash with the 19 wires and four resistors soldered on to fix late production problems (Mitac says the board will be cleaner in later production runs). Its 108 chips include the 80386SX-16, an 80387SX-16, and six Intel VLSI chips that perform most of the MCA functions. Removing the motherboard is slow but not difficult.

A Chips & Technologies VLSI chip provides VGA support. That chip uses eight 256K-byte DRAM VGA memory chips, and there are sockets for eight more. A new C&T chip that will support higher display resolutions will be able to use those extra sockets. The MPS2386's memory consists of 36 100-ns, 1-megabit DRAM chips on four 1-megabyte, parity-checked SIPs on the motherboard. Its keyboard controller and ROM BIOS (version 1.02.00) are by Phoenix Technologies.

The Model 55 SX opens easily, as you would expect from a PS/2: You just undo one screw on each side, and you're done.

The Model 55 SX is a solid, compact machine aimed at the entry-level user who wants an 80386.

The screws even remain attached to the case. Once the case is open, you see a little of the famed PS/2 engineering.

The speaker enclosure forms the front of the card cage and pops out easily. The MCA slots are on a daughterboard that's mounted perpendicular to the motherboard. It and its plastic support brace also come out easily. To take out the drives, you only have to remove their cables, take off the front bezels, and slide them out.

Even IBM, however, makes compromises. The on/off switch on the system's front actually moves a metal bar that extends to another on/off switch on the power supply. The motherboard also was no easier to remove than the MPS2386's; it's held in place by eight little blue screws that were difficult to replace.

The motherboard itself looks great at first: It's the size of a sheet of paper (8½ by 11 inches) and has only 67 chips, not counting memory. Among those chips are the 80386SX-16, a socket for an 80387SX-16, six large IBM VLSI support chips, and eight VGA 256K-byte DRAM chips. There were also 28 chips, including 16 85-ns, 1-megabit DRAM chips, on each of the evaluation unit's two 2-megabyte SIMMs. Surprisingly, the motherboard had 16 wire fixes—almost as many as the MPS2386.

Both systems have respectable keyboards. The Model 55 SX uses the familiar IBM Enhanced keyboard, whose main deficiency is the small size of its Return key. It has a good feel, with mechanical feedback that you can both feel and hear, but it's a little noisy.

The MPS2386 uses a Chicony Electronics keyboard with the common modified IBM Enhanced keyboard. The Enter key is larger than that on the IBM, while the backslash key is to the left of the Backspace key. This keyboard also has a nice mechanical sound and feel, and it's quieter than IBM's.

Both machines include a one-year carry-in parts-and-labor warranty, with extended warranty service and on-site service available. Who services the IBM unit depends on who sells it to you; you go to either your dealer or IBM. Similarly, you get service for the MPS2386 either from your Mitac dealer or from TRW's Customer Service Division, Mitac's service representative.

Mitac provides unlimited telephone support. When the support people called us back, they were helpful, although not well informed about the newly introduced MPS2386. Mitac's phone support is not toll-free, however.

A Question of Need

The Model 55 SX is a solid, compact machine aimed at the entry-level user who wants an 80386. You pay a high premium for the IBM logo: Choose the Model 55 SX over the MPS2386, and you pay over $1000 more and lose the ability to add more hard disk storage. If the IBM name is worth that much money to you, and if you're sure that you'll never need more disk storage, then the Model 55 SX might be the machine for you.

The big question is whether you need an 80386SX MCA machine at all (see "Battle of the Chips," March BYTE, for more on the 80386SX versus the 80286). Frankly, we don't recommend the combination unless you're wedded to MCA and you need to get into the 80386 world as cheaply as possible. If you just want an 80386SX, you'd be better off with an AT-bus Compaq or one of the less expensive compatibles. If, however, you've just got to have this odd combination of the 80386SX and the MCA, the Model 55 SX and the MPS2386 fill the bill. ■

Mark L. Van Name, a BYTE consulting editor, and Bill Catchings are independent computer consultants and freelance writers based in Raleigh, North Carolina. You can contact them on BIX as "mvanname" and "wbc3," respectively.

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Circle 15 on Reader Service Card

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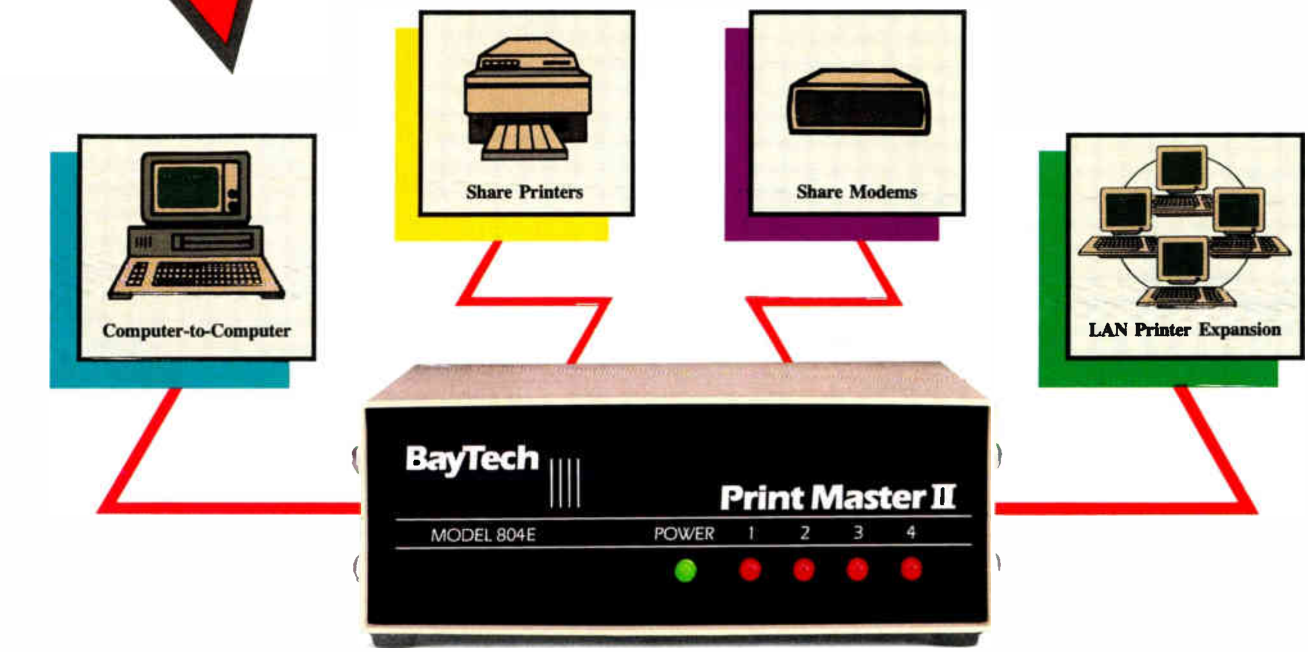

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Circle 33 on Reader Service Card (DEALERS: 34)

Color Printer Quells Price-Tag Blues

ColorQuick offers Mac users a slow but effective alternative to pricey thermal printers

Tom Thompson

Volumes extol the color-imaging capabilities of Macintosh computers, but a single word describes printing those images: expensive. But people who balk at paying $7000 to $15,000 for laser and thermal wax-transfer color printers now have a new alternative, Tektronix's $2495 ColorQuick ink-jet printer for the Mac II and Mac SE/30.

With a 216-dot-per-inch resolution, the ColorQuick doesn't rival high-end printers, but its output looks crisp and vibrant on coated paper. What's more, ink-jet prints are more durable than wax-transfer prints, so, for example, artists can fold proofs for mailing, and the ink won't flake or run if the paper accidentally gets soaked (as has happened to me).

The printer has some limitations, including sluggish text speed. But when you compare its price and operating costs to those of high-end printers, the ColorQuick can be a winner for some applications.

A Generous Host

Color printers are expensive because, in many instances, they come with their own microprocessor, RAM, and firmware to handle networking protocols and page-description-language commands. Rather than duplicating these components, ColorQuick opts to tap the host computer to build page images into memory and transfer color data through the Mac's SCSI port to the printer. (This is the same approach that Apple's black-and-white LaserWriter IISC SCSI printer uses.)

This design trades cost savings for computer downtime: ColorQuick ties up the host for the entire printing operation. This can be especially annoying if you are printing large images or lengthy documents.

Nuts and Bolts

ColorQuick's bidirectional print head builds page images one band at a time as four ink jets simultaneously spray dots of cyan, magenta, yellow, and black ink. A levered cover on the print head allows easy access to ink tanks and seals the tanks securely during printing. Lamps on the top of the front of the printer show ink levels. The tanks that store the liquid inks sit on the print head. Also on the print head is a cartridge containing an anticlogging fluid designed to keep the ink jets flowing smoothly. Easy-to-reach buttons let you select form- or line-fed paper, set the media type, and place the printer on-line.

The printer accepts plain paper, coated paper, and transparency film in cut-sheet, roll, or tractor-fed forms. Cut-sheet and roll feeders come standard; a tractor feeder is available as an option at a cost of $300. Both standard feeders handle up to B-size (tabloid) or A3-size media; you can also hand-feed 12- by 18-inch sheets.

Two 50-pin SCSI ports and a Centronics port let Macs and PCs share the printer. The manual explains how to connect a PC, but you must first determine if your PC applications have the appropriate drivers.

The manual is complete and well illustrated. It points out that the printer

continued

ColorQuick

Company
Tektronix, Inc.
Graphics Printing and Imaging Division
MS 63-447
P.O. Box 1000
Wilsonville, OR 97070
(800) 835-6100

Features
Four-color ink-jet printer prints 16.8 million colors; drivers selected using Macintosh Chooser; two 50-pin SCSI ports and one Centronics port; includes sheet and roll feeders; supports Apple's 32-Bit QuickDraw

Size
5⅓ × 15 × 26 inches (without feeders); 28½ pounds (without feeders)

Hardware Needed
Mac II, IIx, IIcx, or Mac SE/30 with at least 2 megabytes of RAM

Software Needed
System 6.0.3/Finder 6.1 or higher

Documentation
User manual

Price
$2495

Inquiry 851.

doesn't have an internal SCSI terminator. This is nice to know if you're cabling the printer to an external SCSI hard disk drive. Many disk drives have hard-to-remove internal terminators and therefore should be placed at the end of a chain of SCSI peripherals (so the order would be, for example, the Mac, a printer, a tape drive, and then the hard disk drive). You set the printer's SCSI ID by means of a small rotary switch. A self-test switch and configuration DIP switches for PCs sit under a hinged front cover that protects them while keeping them readily accessible.

Although the printer is rated at 216 dpi, the Mac software you use determines the actual resolution. For example, most bit-map-based applications, such as MacPaint or PixelPaint, operate on pixels and will print only at the Mac's 72-dpi screen resolution. Vector-based applications, on the other hand, treat graphics as objects and use Color QuickDraw's drawing primitives for additional resolution.

To achieve this extra resolution with text, you must use a font that's three times larger than the document's font. This is because Color QuickDraw uses these larger characters (say, 30-point Courier) to draw the text at 216 dpi; the text actually appears as 10-point Courier on the page. If the larger font is not installed, you can end up with poorly formed text.

Standard ColorQuick disks provide the large fonts in 11 typefaces: Courier, Times, Helvetica, Helvetica Narrow, Palatino, Symbol, ITC Avant Garde Gothic, ITC Bookman, ITC Zapf Chancery, ITC Zapf Dingbats, and New Century Schoolbook. Although these fonts match the PostScript fonts, remember that they are bit-mapped screen fonts, not PostScript fonts. Also, these additional fonts take up space on your hard disk—over 2 megabytes' worth.

Putting It to Work

My review unit arrived with sheet and roll feeders, spare ink cartridges, and a box of 3½-inch floppy disks. The disks held system software, ColorQuick's printer driver, and the larger fonts. Unfortunately, the printer doesn't ship with a SCSI cable or terminator.

I used ColorQuick with a Mac II running System 6.0.3 with 5 megabytes of RAM and a SuperMac Spectrum/8 video board with a 19-inch color monitor. Although the ColorQuick driver can operate with 2 megabytes of RAM, most color applications require well over 1 megabyte. You might consider upgrading your system RAM to 4 megabytes.

The printer comes filled with ink, so the messiest part of the setup is removing the seal on the print head's ink tanks. You'll probably get ink all over your hands no matter how carefully you do this. However, refilling the ink tanks is easy and clean. Sealed ink cartridges are keyed to prevent you from emptying the wrong color into the wrong tank. One end of the cartridge goes into the appropriate well, breaking one seal; you break a second seal on the cartridge top to let the ink flow into the tank.

ColorQuick sports one of the best printer drivers I've seen because it gives plain-English messages (e.g., "Printer out of paper" and "Put the printer online"). When a problem is flagged, you have the choice of either correcting it and resuming the printing operation, or clicking a cancel button to abort the job. A status window graphically shows how much of the page had been printed before the job halted. The window also indicates ink tank levels.

Smooth Color Blends

I printed images with PixelPaint 2.0, MacDraw 1.1, SuperPaint 2.0, and Cricket Graph 1.0. Line artwork, such as charts and graphs, reproduced best. Most PixelPaint artwork with color blends achieved similar quality. Colors blended in smooth gradations. Interestingly, ColorQuick handled some blends (red to yellow to green) better than others (purple to red), but this may be due to a combination of factors and not just the printer.

Although MacDraw 1.1, Cricket Graph 1.0, and SuperPaint 2.0 use the original eight QuickDraw colors, ColorQuick will accommodate those who still use these applications. The driver does require Color QuickDraw, however, so you can't coax colors out of, say, MacDraw 1.1 using a Mac SE or a Mac Plus.

PageMaker 3.0 documents, including the hairlines and colored text, printed fine. However, PageMaker and text-only documents printed slowly: It took nearly 2 minutes per page on low resolution (72 dpi) and over 3 minutes at high resolution (216 dpi). Speed is significant, since printing ties up your Mac. You can't even run the print job in the background under MultiFinder.

Scanned color images were hit-and-miss: Either the printed image looked good, or it didn't. I couldn't determine the cause of this inconsistent quality, especially when I printed two images with nearly the same set of colors, and one looked awful and the other looked sharp and colorful.

You should use coated paper for best results. Images printed on regular paper appeared muddy and flat. Tektronix estimates that coated paper costs 28 cents per sheet. You can expect to pay approximately 40 cents per sheet or more with thermal wax-transfer printers.

ColorQuick's sluggishness when printing text makes it a poor general-purpose printer. However, it shines with artwork, printing most of it at the rated 216-dpi resolution. The nearest price competitor, the $1395 Hewlett-Packard PaintJet, prints at only 180 dpi.

For the right color-printing applications, such as artist's proofs or color transparencies for business presentations, ColorQuick is an affordable and effective choice. ■

Tom Thompson is a BYTE senior technical editor at large. He can be reached on BIX as "tom_thompson."

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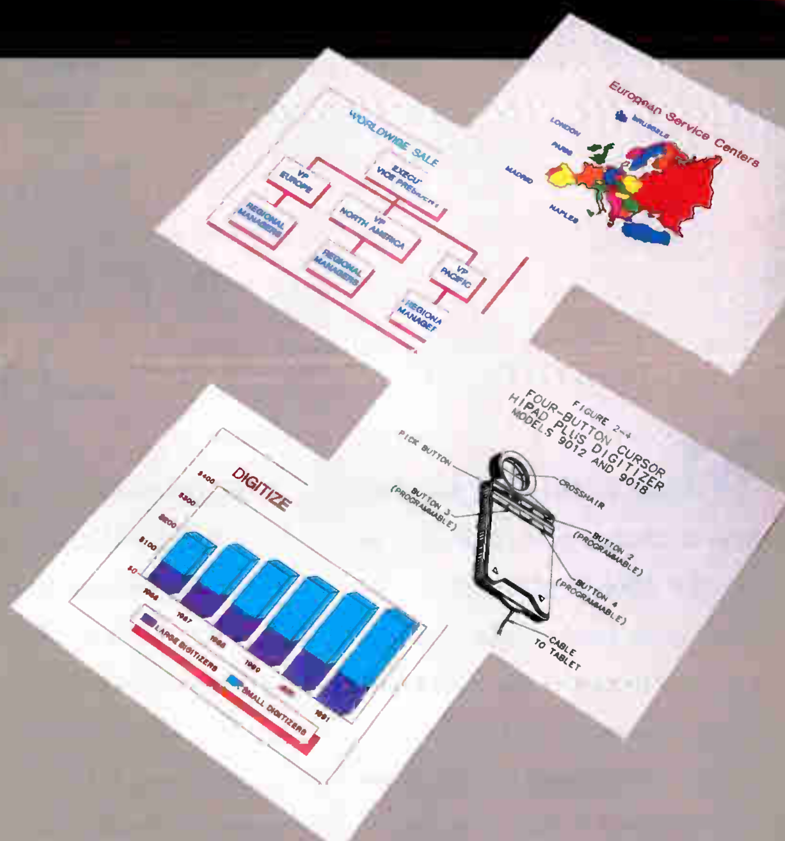

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Speed Separates Two Portable Printers

Kodak and Toshiba take different routes to design printers for the road

Wayne Rash Jr.

Portable printing: The Toshiba Expresswriter 301 (left) and the Kodak Diconix 150 Plus.

Kodak and Toshiba recently introduced portable printers for laptop-toting business travelers. Kodak's printer shines as a compact and efficient touring companion; Toshiba's does not.

Kodak's success stems from the ink-jet printer head that it uses with the Diconix 150 Plus, an updated version of the Diconix 150 thermal printer. Toshiba opted for a thermal print mechanism in its Expresswriter 301, and the result is letter-quality output at an almost impractical speed.

To be effective, your portable printer should be as compact as your laptop computer. Ideally, the printer should fit into the computer's carrying case and run on batteries. Its print quality shouldn't embarrass you, even if it falls short of laser printer quality. The Kodak and Toshiba printers each fulfill some of these requirements, but when they're compared for speed and other practical matters, their similarities end.

Slow but Sure

The Expresswriter is misnamed. "Express" implies speed, and that's a quality missing entirely from this, the slowest printer I have ever reviewed.

Clearly, Toshiba optimized the Expresswriter for print quality at the expense of speed and ease of use. Fanfold paper won't work, so you must insert each sheet individually. The paper-out indicator signals before the print head actually reaches the bottom of a page—but that's just as well, because the platen loses its grip on the paper at about that time, so if anything printed, it would be crooked.

The Expresswriter's actual per-line throughput is a dreadful 12.8 characters per second at regular speed, and 16.6 cps at "high" speed (see table 1). (Toshiba claims a high speed of 60 cps.) This rate grinds even more slowly over an entire page, because the head prints only in one direction. At the end of each text line, the head pauses, makes some internal clicking sounds, and then slowly returns to the left margin to begin a new line.

If you can accept this agonizingly slow speed, you'll be pleased with the crisp results from Toshiba's 24-pin thermal print head. It won't outshine a laser printer, but it's acceptable for most business uses. Unfortunately, that's about the only thing I found acceptable in the Expresswriter.

The unit promises Toshiba 321 SL and Epson LQ-850 compatibility. The Epson compatibility worked fine with WordPerfect 5.0 and WordStar 5.5. WordPerfect also handled the Toshiba emulation,

continued

Diconix 150 Plus

Company
Eastman Kodak Co.
Personal Printer Products
901 Elmgrove Rd.
Rochester, NY 14653
(800) 255-3434

Features
IBM Proprinter, Epson FX-80/85, and IBM Graphics emulation; 2000-character buffer; draft, near-letter-quality, and quality modes; condensed superscript/subscript print; noise: 45 dB
Power: AC adapter; five rechargeable C cell batteries (life: 12 hours standby, 1 hour printing)

Size
2 × 6½ × 10¾ inches; 3 pounds

Documentation
User's guide; reference manual

Price
Parallel model: $499
Serial model: $519

Inquiry 852.

Expresswriter 301

Company
Toshiba America Information Systems, Inc.
9740 Irvine Blvd.
Irvine, CA 92718
(714) 583-3000

Features
Toshiba 321 SL/Qume and Epson LQ emulation; 2000-character buffer; 24-dot print head; noise: 47 dB
Power: AC adapter built-in; rechargeable 1 hour of continuous printing

Size
3 × 5½ × 12¼ inches; 4 pounds

Documentation
User's manual

Price
$489

Inquiry 853.

Table 1: *Even at its slowest setting, Kodak's Diconix 150 Plus outpaces the Toshiba Expresswriter 301's printing speed. (Tests consisted of a 1000-character ASCII text file. Measurements are in characters per second for throughput at 10 pitch.)*

Diconix 150 Plus	Expresswriter 301
Draft: 99	Regular speed: 12.8
Near-letter-quality: 33	High speed: 16.6
Quality: 24.2	

but WordStar did not. However, considering that virtually all software accommodates Epson printers in some way, LQ-850 emulation is acceptable.

For this review I used a Zenith SuperSport 286 portable computer. Its carrying case sports a 10- by 12- by 2-inch pocket into which I usually stuff the computer's power supplies, cables, software, LapLink cables, Ethernet cards, a Travis McGee mystery, and, if possible, the printer. Unlike the Diconix, the Expresswriter didn't fit into the pocket. But the Expresswriter is rugged enough to pack into your checked luggage. It survived a rail trip from Washington, D.C., to Philadelphia with no ill effects, although it was inaccessible for any in-transit work.

Jet-Propelled

In contrast to the Expresswriter, Kodak's Diconix 150 Plus is compact, easy to use, and reasonably speedy. Its acceptable print quality falls short of the Expresswriter's, but the text prints a great deal faster. The Diconix's ink-jet printing head provides the speed and size advantages. The updated Diconix also accepts single-sheet or continuous-form paper, so I didn't have to hover over the machine during an extended printout.

The printer appears to be a direct descendant of the old Hewlett-Packard ThinkJet. While the original had problems, such as ink splattering and an appetite for special paper, Kodak's version overcomes these shortcomings. Still irritating, however, is the Diconix's tendency not to print the last line of a text file unless it's followed by a formfeed character. This command, common for laser printers, is unusual for dot-matrix models. It proved tedious when I sent ASCII text to the printer using the MS-DOS COPY command. The command was unnecessary when I used word processor or spreadsheet applications.

Overall, the Diconix 150 Plus behaves well and prints quietly. It supports WordStar and WordPerfect, and both the Epson FX-80 and the IBM Proprinter emulation modes worked properly.

In draft mode, the Diconix runs at 99 cps average throughput for 10-pitch printing (Kodak promises 97 cps average). Draft mode is just that: The print is clearly ink-jet dot-matrix quality, which is fine for draft memos but not business letters.

Diconix also offers near-letter-quality and "quality" printing. Each adds printhead passes, so speed slows accordingly compared to draft printing. But the quality-mode output looks nearly as good as the Expresswriter's text, which takes nearly twice as long to print. More important, you don't suffer with a slower speed unless you choose higher-quality results.

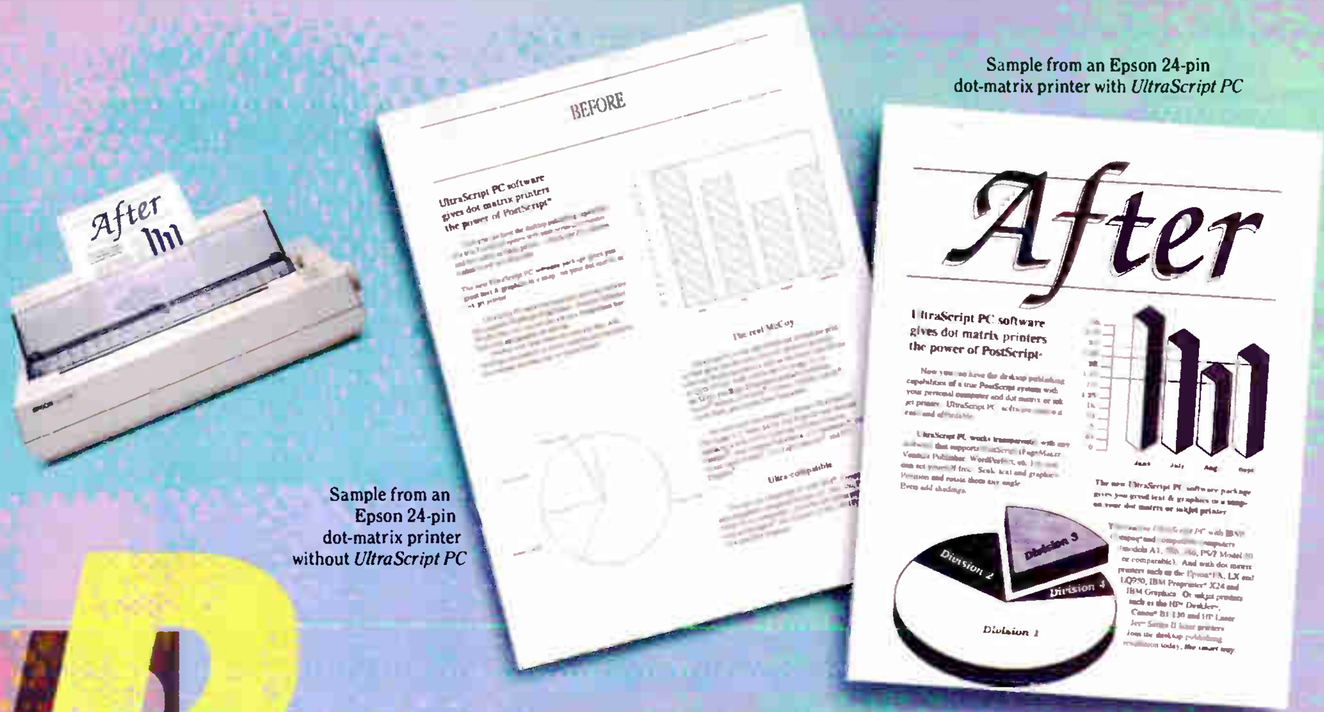
The Diconix performs admirably as a travel printer. I took one to Honolulu, where I used it to create documents that I then faxed to my Washington, D.C., office. The printer was quiet enough to use in my hotel room without concern. Because it fit easily into my laptop's carrying-case pocket, I could work whenever I had the opportunity, including in a Honolulu airport lounge. The larger Toshiba would have been out of reach in my checked baggage.

Which Do You Need?

If you're considering buying either of these printers, first decide if you really need letter quality. The Expresswriter offers this, but it asks you to sacrifice performance and easy portability.

With only slightly lower print quality, the Diconix is fast, light, and practical. It travels easily and performs well where you're likely to use it. In short, it works in the real world of business travel, and the Expresswriter does not. ■

Wayne Rash Jr. is a contributing editor for BYTE and a member of the professional staff of American Management Systems, Inc. (Arlington, VA). He consults with the federal government on microcomputers and communications. You can contact him on BIX as "waynerash," or in the to.wayne conference.



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Sample from an Epson 24-pin dot-matrix printer without *UltraScript PC*

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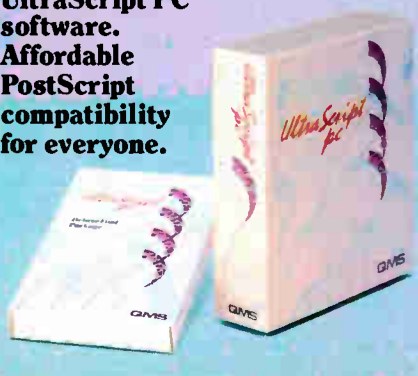

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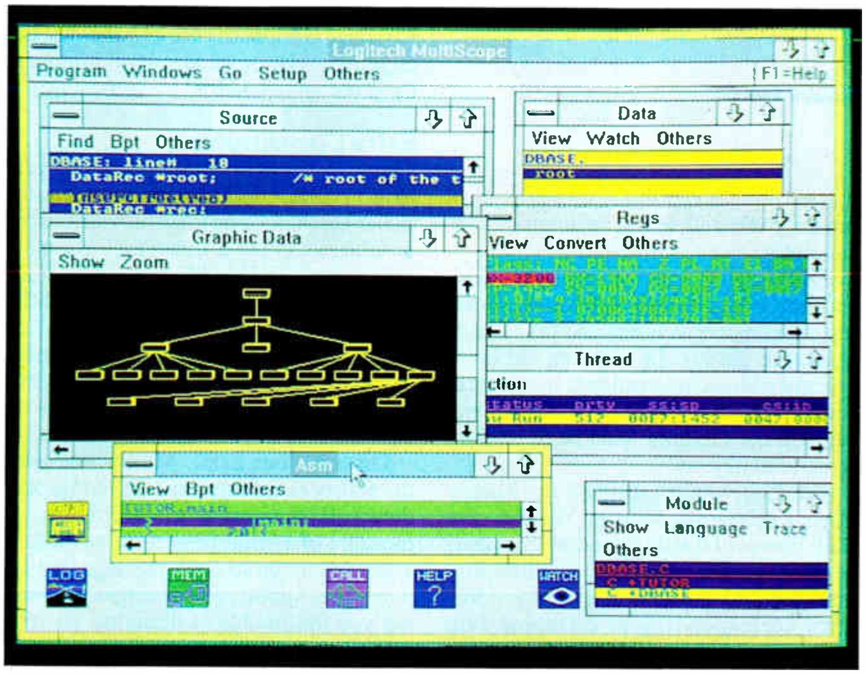
Martin Heller



MultiScope's Graphic window builds pictures of structured data objects.

Event-driven, multitasking programming environments like the OS/2 Presentation Manager (PM) require good debugging tools. Until now, you had only one choice: Microsoft's CVP, a protected-mode version of the CodeView symbolic debugger. Now there's an alternative: Logitech's MultiScope.

Like CodeView, MultiScope works with multiple languages and helps you debug threads, child processes, and dynamic link libraries (DLLs), but it's more comprehensive. The MultiScope package comprises four debuggers: the PM Run-Time Debugger, PM Post-Mortem Debugger, Text Mode Run-Time Debugger, and Text Mode Post-Mortem Debugger.

The run-time versions, like most debuggers, monitor your program as it executes. The postmortem versions, in conjunction with a special utility that saves your program's state in the event of a crash, let you resurrect and examine the static context of a crashed program. The postmortem debuggers really set MultiScope apart, since you can easily spend hours sneaking up on a protection violation using a run-time debugger.

The MultiScope debuggers work during or after run time, under PM or in character mode, and on the same computer as the program being debugged or on a remote machine. That's quite a feat. Even better, Logitech has made the debuggers all look much the same, so that there is little transition to make when switching among them. Logitech has also kept its debuggers compatible with the format used by CodeView and generated by Microsoft C and Microsoft Link. And you can use MultiScope in conjunction with Logitech's own Modula-2 for OS/2.

The Big Picture Through Small Windows

The MultiScope debuggers are organized into as many as 14 windows. (Some windows don't apply to all situations.) Naturally, things look best under PM, but the windows appear in text mode, too. The Assembly window shows your disassembled and source code. At run time, you can set breakpoints on the assembly code, get statement addresses, and jump to code lines.

The Breakpoint window (available only in the run-time debuggers) lists the line number, module location, and conditional expression for each breakpoint. You can modify breakpoints in this window; for instance, you can add a pass count to create a delayed breakpoint.

The Call window displays the chain of procedure calls in a thread. From the Call window, you can select a procedure to be displayed in the Source and Data windows.

The Data window displays global and local variables for the currently selected procedure in the current thread. It has facilities for modifying values (at run time), exploring arrays and structures, launching the graphical data display

continued

MultiScope

Company
Logitech, Inc.
6505 Kaiser Dr.
Fremont, CA 94555
(800) 231-7717

Hardware Needed
OS/2-capable PS/2 or AT compatible, 4 megabytes of RAM, and a hard disk drive; a mouse is recommended

Software Needed
OS/2 Standard Edition or Extended Edition 1.1 or higher

Price
$299

Inquiry 885.

(under PM), and setting watchpoints (at run time).

The Graphic window displays a box-and-line graph of data structures, showing data objects as boxes and pointers as lines (see photo). In addition, different types of objects are displayed in different colors. As with the Data window, you can use the Graphic window to explore structured objects.

The Log window displays the history of your debugging session. You can save the contents of the Log window to a file if necessary. The Memory window displays memory contents in a variety of formats corresponding to different data types, and it has facilities for adding watchpoints, modifying data, and converting hexadecimal numbers to and from decimal.

The Module window displays the object modules that make up your program. You can set the source language and enable or disable tracing on a module-by-module basis. From the Module window, you can also control the Data and Source window displays.

The Output window displays the screen produced by the program being debugged. The Register window displays the register, flag, and coprocessor register values for the currently selected thread. You can modify the registers (at run time) and do hexadecimal-to-decimal conversions.

The Source window displays the source code of the currently selected module. You can set breakpoints (at run time), search for procedures and lines, jump to lines, and get statement addresses. The Thread window lists your program's threads of execution and their status (e.g., runnable, frozen, blocked, and critical section), priority, stack location, and code location. You can freeze and thaw threads, as well as control the display of the Source, Data, Call, and Register windows.

The Watch window displays your (run-time) watchpoints, which are generally set in the Data or Memory windows. In the Watch window, you can control the "granularity" or frequency of MultiScope's watchpoint checking—each variable watched can be checked at every assembly instruction, every source statement, or every procedure entry. Given the overhead involved in checking data variables without the use of hardware debugging tools, procedure-level granularity is recommended.

Extra Conveniences

The run-time MultiScope debuggers have 11 different Go commands—a much richer set than CodeView provides. Both programs can trace individual assembly instructions and source code lines, trace into or over individual procedure calls, and run until the next breakpoint or watchpoint or the program's end. CodeView's Execute command, which runs your program in slow motion, has no equivalent in MultiScope.

On the other hand, MultiScope adds the ability to execute until the next procedure call, the next procedure return, or the start of a child process or session. It also adds a "go to end" message that ignores breakpoints and watchpoints, saving you the trouble of disabling all your diagnostics when you just want the program to terminate cleanly.

MultiScope's Go commands correspond well to the way I debug, so they save me time compared to the way I use CodeView. But I found the biggest time-saver to be MultiScope's MED (for monitor execution dump) and postmortem debugging facility.

Normally, when a program crashes under OS/2, the user gets a message that says "protection violation," along with some meaningless addresses. Why the program crashed remains a mystery; the OS/2 trap handler doesn't even provide a stack trace, much less a core dump. Sometimes the user can isolate the problem empirically by keeping track of keystrokes and mouse-clicks, but all too often the following dialogue ensues.

User: "Your program crashed."
Developer: "What were you doing?"
User: "Nothing. It just crashed."

With MED, the situation is a little different. The test version of the program is compiled with a call to MED's initialization routine. Until the program crashes, it runs at full speed, with no interference from MED. When the program crashes, MED takes over and saves the full state of the program in a memory-dump file. The user sends the developer a copy of the dump file, which the developer diagnoses with the Post-Mortem Debugger.

Since MultiScope's postmortem debuggers can do everything its real-time debuggers can do except run the program, finding the cause of the crash is fairly easy. For instance, you can unambiguously identify a null pointer (a common error in C programs and a common cause of protection violations) by double-clicking in MultiScope's Call window and then examining the highlighted line in the Data window.

MultiScope's graphical interface makes it much easier to learn than CodeView. You can learn to use MultiScope with a mouse and the menus in an hour or two. Learning all the mouse and keyboard shortcuts will take a little longer, but if you use the program a lot, you'll want to learn them.

With complex data structures, MultiScope again comes up a winner. You can see inside your structures to figure out what's going on by using the Graphic data window. It's a pity the Graphic window only works in the PM versions of the debuggers. I'd like to be able to use it on PM programs, but you can't run the PM debugger on a PM program; if you try, your machine will hang up.

A Few Problems

The conflict between a PM debugger and a PM program is serious, and it may not be soluble under OS/2 1.1. According to Logitech, the problem is that PM's message dispatcher has only one thread. If any PM application fails to respond to a message, the whole PM screen group grinds to a halt. Since the application being debugged *has* to be suspended at a breakpoint or watchpoint, it will not respond to messages. If the debugger is also running in the PM screen group, the debugger will not get any messages. Result: total hang-up. For now, developers can use either MultiScope's character-mode or remote debuggers for debugging PM applications.

The remote debugger lets you have a PM environment running on both the application and the debugger, but it requires two machines that run PM. It would be nice to do this with less of a hardware investment.

continued

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Hardware is an issue, too, when simply running the debuggers. With 14 windows to look at, screen real estate is at a premium. Logitech has provided a partial solution in the form of a reduced-size screen font. But anyone who wants to see more than four or five windows at once would do well to look into high-resolution video cards for OS/2, such as the Video Seven VRAM VGA (which can display the PM screen at 800 by 600 pixels on a good multisync monitor) or the IBM 8514/A.

Another problem occurs when viewing variables in local scopes. In the following example, the third instance of `i` is inaccessible:

```
int i,j,k; // globals
main() {
 int i,l,m;
  // local to main()
 (intervening code)
 if(j>k) {
    int i;
  // i inaccessible to debugger
    for(i=0;i<m;i++)
       do_something_with
          (i,j,k,l,m);
    }
(intervening code)
 exit(0);
 }
```

This problem, which isn't serious, comes from the Microsoft C Compiler, which simply doesn't generate debugging information for variables in local scopes. You can always rename your variables and move them up to the function level.

A Worthwhile Investment for Professionals

Perhaps the most serious problem facing MultiScope is not technical at all: CodeView is supplied free with Microsoft C. Occasional OS/2 programmers who got CodeView for free might not want to pay for MultiScope.

On the other hand, serious OS/2 programmers can easily justify the $299 cost of MultiScope by increased productivity. Just one workday saved—for instance, by using MED and postmortem debugging to identify a bug that only happens at a customer's site—should repay the cost of MultiScope. And continued use should pay back handsomely: Logitech has a good set of tools here, which should only improve with time. ■

Martin Heller develops software and writes about technical computer applications. He holds a Ph.D. in physics. He can be reached on BIX as "mheller."

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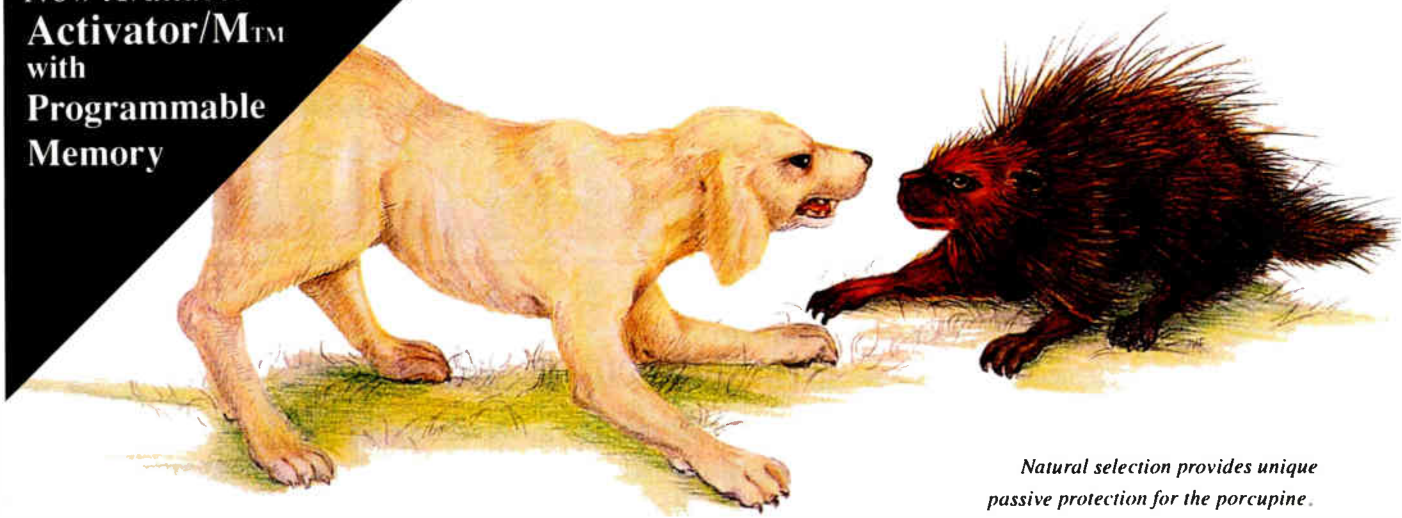

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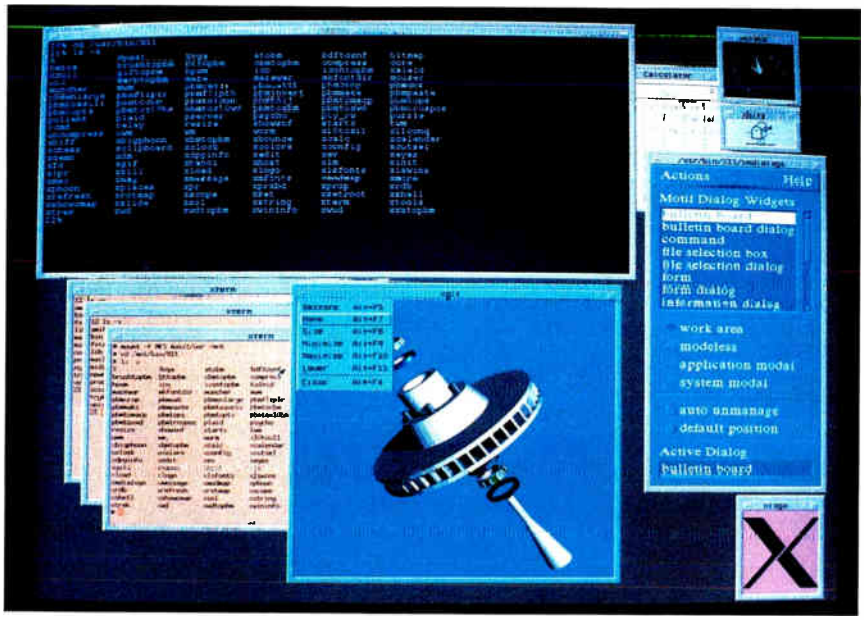
X Window System on the March

Interactive Systems' 386/ix X11 implements the graphical Unix standard with style

Tom Yager



Interactive's 386/ix X11 with the Motif window manager.

The X Window System has emerged as a graphical user interface standard in the Unix world, for all the right reasons. It isn't owned by any one company, and it's highly portable. Interactive Systems Corp.'s X Window System product, 386/ix X11, works in conjunction with ISC's 386/ix, a port of AT&T's Unix System V release 3.2. The 386/ix package was the first commercially available 3.2 Unix for the 80386, and it remains the most widely accepted. It's efficient, stable, and rich with features. The 386/ix X11 package, the layered X Window product reviewed here, shares those qualities.

I tested the system using two SIVA 386/20 PCs from VNS America. Each had 8 megabytes of memory and a 300-megabyte SCSI hard disk drive connected to an Adaptec AHA-1540A/1542A controller. Each machine also had a 16-MHz 80387 math coprocessor. The network connection ran through a pair of Western Digital WD8003 Ethernet adapters.

One system sported an Orchid ProDesigner VGA display adapter with 512K bytes of memory, and the other system had a Matrox PG-1281 34010-based graphics coprocessor. The Orchid VGA adapter drove a Seiko CM-1430 14-inch multifrequency monitor, and the Matrox was hooked to a 19-inch Mitsubishi Diamond Scan Model HL6905. Each system had a Logitech serial three-button mouse.

Taking the Plunge: Installation

Installing 386/ix X11 is simple and automatic. The command `sysadm installpkg` responds with a prompt for the first disk of the series, and then it's easy from there. The X11 package requires kernel (device driver) support, but this poses no difficulty even for the Unix novice. The installation process automatically rebuilds the Unix kernel to accommodate the new devices.

The installation process binds a set of interactive maintenance programs into the `sysadm` utility's menu tree. After the kernel support has been linked in, menus guide the administrator through setting up the environment. The device-dependent portions of the 386/ix X11 servers come in object form. You simply select from a list of supported servers, and each is quickly linked together from the object files. Most can drive a wide range of adapters. The VGA server, for instance, only needs to be built once, even if you plan to use several cards and display geometries. You can build and install new servers anytime, so changing boards is no hassle.

The combination of an X11 server, a keyboard, and a mouse form a logical group called a *display*. The keyboard and mouse types are presented in menus; however, since each server supports so many different graphical configurations, you have to enter a string to identify the screen resolution, the size, and the number of colors.

The manual lists the appropriate configurations for each supported server type. The file `/usr/lib/X11/Xconfig` contains nearly all the specifics as well. Each logical display has one clearly marked adapter, keyboard, and mouse

continued

386/ix X11

Company
Interactive Systems Corp.
2401 Colorado Ave.
Santa Monica, CA 90404
(800) 346-7111
(213) 453-8649

Hardware Needed
80386-based AT compatible or PS/2 with 4 megabytes of RAM, a Hercules or VGA adapter, a two- or three-button mouse, and a 60-megabyte hard disk drive; an Ethernet adapter is required for networking

Price
Various configurations are available:
Workstation Starter (includes the 386/ix operating system and 386/ix X11): $495 (single user); $795 (multiuser)
Workstation Extender (adds the 386/ix TCP/IP, the 386/ix NFS, and the VP/ix): $1095 (single user); $1895 (multiuser)
Workstation Developer (adds development support for 386/ix and 386/ix X11): $1995 (single user); $2995 (multiuser)

Inquiry 883.

entry in this file, and all the configurations under each category appear in commented form.

Two levels of X11 are available from ISC. The most basic, the run-time system, comes with ISC's Run-Time System Guide, which describes the installation procedure and the commands. The development system adds another ISC manual to cover the development libraries, but the largest of the documents are the two Xlib (X function library) manuals. One acts as a guide, and the other is a reference. They both cover the X11 function library completely, and the guide doubles as a fair tutorial.

Starting and Running 386/ix X11

If you're an experienced X11 user, you'll find yourself on familiar ground. If a default server was specified during configuration, you need only type `xinit` to start. The screen clears, leaving an X-shaped mouse cursor in the center of the screen. The default for `xinit` is to create one black-on-white terminal window in the upper left corner of the screen. You can, however, set your own color scheme and start up client programs.

Tailoring your environment is simple. When `xinit` starts, it tries to execute a shell script called `.xinitrc` in your home directory. The default terminal window, along with other terminals, applications, and visual toys, can be started from here.

The X11 server also allows the default server-specific behavior to be overridden through a similar mechanism, the file `.xserverrc`. This one-line script contains the name of the server (such as `Xvga` for the EGA/VGA server) and appropriate command-line arguments. Other X11-related configuration files are supported in the standard fashion, allowing you the freedom to change the appearance and behavior of any conforming X Window System application.

ISC also provides `xdm`, X11's own session manager. This program fires up the server and creates a log-in panel. It prompts for the user name and password and then starts up client programs based on settings in various configuration files located in `/usr/lib/X11/xdm`.

X11 itself does not enforce any policies regarding how to manipulate windows. In fact, the default setup gives you no way to move, resize, or otherwise maneuver them. A special client program, called a window manager, handles these functions, and ISC's X11 distribution supplies three: `uwm`, `wm`, and `twm`.

Of these, the most useful is `twm`. It is highly configurable and builds clean, readable frames around clients. At the top, `twm` adds a title bar with the client's name, along with boxes with symbols for resizing, iconifying (i.e., replacing the application window with a small box containing the client's title and, optionally, a graphical depiction of its purpose), and attaching keyboard input to the window. Optionally, you can create an icon box. This box lists each client program's name, and clicking the mouse's left button on a name toggles the program's iconified/expanded state.

The `twm` is one of dozens of user-contributed programs on seven disks. Many productivity-impeding toys are mixed in with the better utilities, but these programs make X11 a joy to use. In my view, no release would be complete without them. Many vendors ship only the core programs necessary for operating X11, along with a weak assortment of clients. ISC is sure to win points with X11 newcomers by including these programs.

Operation is generally smooth. The VGA server, running with the Orchid board at 1024 by 768 pixels, drove the display with accuracy but with some performance problems. The sluggishness is most severe when moving large terminal or application windows. The window is repainted in its new position very slowly, from top to bottom, taking as much as several seconds to complete. Oddly, other operations involving large areas of display memory are not so slow. In fact, moving a window is the only operation that exhibits this problem. Creating, destroying, iconifying, and deiconifying work very briskly by comparison. It's obviously faster to re-create the window from scratch than it is to move it as an image.

Most of my complaints about X11 concern its performance. It is possible to get more from the hardware than ISC did. The Matrox board does not get pushed near its potential. X11 performs many operations a pixel at a time, rather than telling the board something like "draw a circle of diameter *z* at position *x*,*y*." For example, the `xdemo` program, when drawing ellipses, runs hardly any faster on the Matrox board than on a VGA. Other shapes do better, and ISC designers trusted the Matrox board to handle the most common graphical element, the thin line.

This disparity between the finely tuned and the barely tolerable puzzles me the most. Engineers at ISC explained that they had to work within the boundaries of MIT's X11 server model. This model, they said, dictates that only certain graphics operations can be handled asynchronously, because the server needs to know when an operation is finished. Thin (default width) lines are a special case and can be handled by the hardware. Nearly everything else is drawn, one pixel at a time, by the X server itself.

In a similar vein, the specialized VGA cards are not used to their potential. The most obvious case is ISC's failure to support any VGA board in a 256-color mode. According to ISC, the change from 16- to 256-color mode is so drastic that a new server would have to be written to accommodate it. That's a lot of work, but I think it would be worthwhile for special cases, such as viewing and rendering artwork and for testing advanced user interface designs.

There are other oddities that need to be addressed as this product matures. For example, the servers seem to take up more and more memory as they run, causing problems in other parts of the system. And there's a problem with virtual terminals. The VGA server operates

continued

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transparent networking is that any computer running an X11 server can connect to the network, even if it isn't able to run any client programs. The recent introduction of X terminals illustrates this. With a minimal operating system and an X11 server in ROM, these terminals use an Ethernet or serial connection to interact with X11. They run nothing but the server and have no other computation capability. They use a specified host to download fonts, and sometimes binary programs (like the server or configuration utilities), so no disk is needed.

X Marks the Spot

ISC's 386/ix X11 arrived a few weeks ago, and it has been that long since I've done anything on an ordinary text display but type `xinit`. It's easy to grow accustomed to, and even dependent on, X11, and the professional manner in which ISC handled its implementation makes it that much more compelling. It is rich with extra features that other vendors have deemed unnecessary. Additional fonts and demo programs have great value even for the experienced user.

Applications developers (and interface hackers) are currently the primary audience for X11, but it has considerable value as an overall environment, too. Those who don't plan to write programs for it will reap benefits just from running it. I expect that, like the Macintosh and Amiga, it will have the effect of turning some users into programmers. Programming under Unix can be enjoyable in itself, but once you add the myriad fonts, colors, and widgets to the mixture, the thrill you feel when first running your own creation is magnified tenfold.

Despite problems that could have sprung from rushing its release, 386/ix X11 is award-winning. The VGA server supports most EGA and VGA cards in all their available resolutions, giving users an inexpensive path to get started with X11, and then to upgrade without sacrificing compatibility. I would like to see a 256-color version, and I expect it will be forthcoming. The VGA support is the heart and soul of 386/ix X11, and it is tremendously well built considering its youth. And there's good support for high-end graphics adapters as well.

Work needs to be done. Functions that hardware can handle without CPU intervention must be removed from the device-independent portion of the server and into the hardware drivers. While the Matrox PG-1281 speeds every operation, only line drawing and blitting (i.e., moving graphics from one area to another) show overwhelming improvement. Matrox's own engineers helped ISC build in support for their hardware, so perhaps the future will bring a more finely tuned server. That tuning will have to include better handling of resources, and some means for telling the server to dump everything and start over.

But 386/ix X11 is a big win for ISC, and the real winners are the users and developers who have been waiting for it. Now the small software house, the student, the consultant, and others who can't afford the big iron can still develop for it, and those that can afford it will have a burgeoning new market for their wares. This may be the best first-release product I've seen, and it will occupy a place of honor in my lab. ■

Tom Yager is a Unix software engineer and freelance technical writer. He maintains a Unix test lab in Westborough, Massachusetts. He can be reached on BIX as "tyager."

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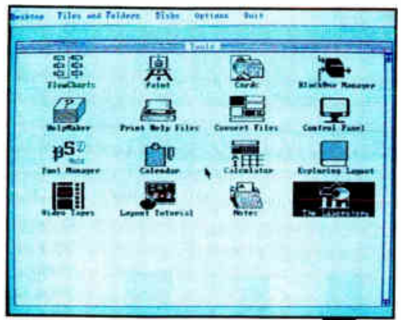

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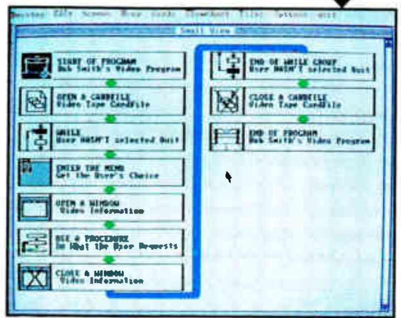

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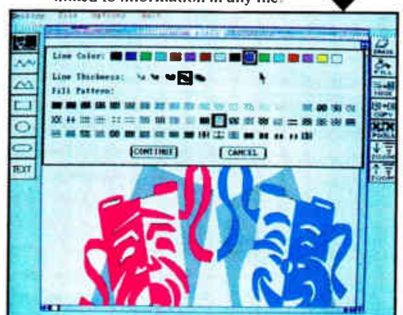

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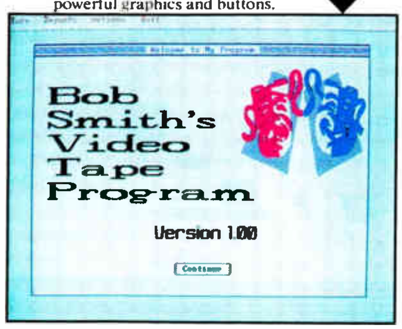

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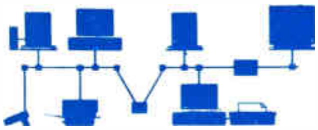

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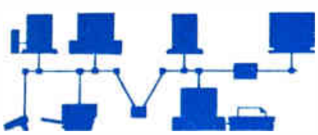

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Visually Map Your Data

MapInfo turns raw data into meaningful presentation graphics

Stan Miastkowski

In today's confusing world of graphics software, MapInfo 4.0 is a unique program. It actually lets you do something eminently useful with any data that contains street addresses or other geographical information. Although its name suggests a simple map generation program, MapInfo is much more. By linking a wide range of data to map files, it gives you a surprisingly new and effective way to look at data.

In a nutshell, MapInfo presents a map (e.g., of a town, county, state, or country) that ties into your database. MapInfo can, for example, pinpoint precisely where a company's customers are located. Or you could have MapInfo show all customers within a 50-mile radius from Chicago, show all customers who bought red widgets, and so on.

Essentially, MapInfo provides a graphical representation of any sort or search you perform on your database. The end result of a MapInfo session is a visualization of "what if." The range of potential applications is almost limitless.

MapInfo's maker, Mapping Information Systems, also offers several hundred different maps onto which you can plot your ASCII or dBASE III data. MapInfo comes with maps of countries, states, and U.S. ZIP codes, and the company also sells digital street maps of thousands of U.S. cities, maps of counties, and demographic/census data. Prices range from $95 to $7000. If you're ambitious, you can even scan in your own map.

MapInfo can produce thematic data maps such as this one of Manhattan showing average household income in various locations around the city.

The Big Map

MapInfo is a large program; the minimum amount of hard disk space you'll need is 3 megabytes. Loading the national ZipInfo file that comes with the package requires another 2.2 megabytes. Then there are the optional maps, if you use them. Even though they're not bit-mapped graphical images (MapInfo stores its data in a dBASE-compatible file format), the very amount of data required means lots of megabytes. Individual map files take up as little as 1 megabyte to as much as 100 megabytes.

The basic MapInfo package comes on 10 packed 5¼-inch floppy disks. (Six 720K-byte 3½-inch floppy disks are also included.) MapInfo's automatic installation utility copies, combines, and unpacks the data. By the time I installed a tutorial, a demo package, and two maps of Boston, Massachusetts, and Nashua, New Hampshire, MapInfo took up almost 20 megabytes of hard disk space.

Since MapInfo is a unique package, it takes a good deal of getting used to, and you have to learn many new terms and concepts. MapInfo's tutorial map package is well worth the trip, but it's only a small step along the way to getting comfortable with the package. The tutorial lessons are essential, but many of my questions were left unanswered, and I frequently got the message "This concept isn't covered in the tutorial."

After loading in maps of Boston and Nashua, I started up MapInfo and found that these cities weren't on the list of available maps. That's because MapInfo doesn't make maps available for use until it knows about them. You need to use an

continued

MapInfo 4.0

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Documentation
User's guide; command reference

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Inquiry 884.

ADD command that's buried several menu levels down, and then the map will appear on the list. Surely the program's designers could have improved the user interface by having MapInfo automatically make new maps available.

Layers of Complexity

Although you see a complete map on the screen, the package actually stores data in four different kinds of files. More precisely, each map consists of four layers of different information.

Boundary files are areas on the map that are completely enclosed by connected line segments. The most common types of boundary files are states, cities, towns, and counties. But depending on the type of map you're using and what data you've added to it, a boundary file can also contain data such as ZIP code areas, sales territories, or census information (to name a few).

Map files contain information about line segments. Streets, highways, and rivers are the most common; specialized applications can contain segments such as utility lines, cable networks, and railroads.

Point files contain information about related points. You'll use this file regularly when you import your own data to MapInfo; the program uses it to locate a position. Depending on your application, a point can be something as simple as a building, a city, or a customer location; or something more esoteric such as a utility pole or even pothole locations. Point files are stored in dBASE III format; each point is a record, and each field contains the additional data (e.g., a customer name) associated with a record.

Image files are the key to MapInfo's presentation graphics feature. Using MapInfo's image-generating features, you can add titles, legends, icons, identifications, and distance scales to your finished map.

Once all the files are put together, what you see on the screen is a complete map that incorporates all the individual features. Depending on the map, you can move the cursor around on it, magnify sections, and locate points, boundaries, and so forth.

dBASE and Geocoding

Although moving around MapInfo's existing maps is diverting, the key to the package's power is its ability to let you integrate your own data into a map. The MapInfo package includes MBase, a dBASE III–compatible database from FoxBASE. MBase is designed specifically for preparing data for use with MapInfo, and it doesn't include any programming capabilities. You also can't run conventional dBASE III programs in MBase. It does, however, let you use any dBASE III commands individually.

If you're familiar with dBASE III, you won't have any problems with MBase. If you're not, the learning curve for getting useful work out of MapInfo gets steeper. If the database you want to use with MapInfo isn't in dBASE III or ASCII format, you'll need to convert it. I used Paradox 3.0's export utility to convert a newsletter subscriber file to dBASE III format for use by MBase.

Just importing your data into MBase, however, doesn't make it usable by MapInfo. You still need to go through several steps of preparing the data for use with maps. The first step is creating a point file for the database. This involves adding *x*- and *y*-coordinate fields to each of the records in your database. Although the process isn't difficult, you have to be familiar with MBase to do it. (You can also incorporate the fields using your original database before importing it into MBase.)

Once your database contains a point file, the next and most crucial step is to "geocode" the point file. Geocoding, the primary tool for getting your data to actually appear on a map, is the process of assigning a coordinate (either latitude/longitude or *x*-/*y*-coordinates) to each data point. In most cases, MapInfo automatically does the geocoding. Which field you choose to geocode on depends on your context. If you're using one of MapInfo's optional city maps, you'll want to geocode on the street address. But if you have clients scattered around the country, you'll want to geocode on the ZIP code.

Once you've chosen which field to geocode on, MapInfo goes through your database and assigns values to the *x*- and *y*-coordinate fields you created in the database. Then you're ready to use your database. Once I geocoded my newsletter mailing list. I overlayed it on the U.S. map, and it showed me graphically where subscribers were located. I could also locate individual points by typing in other data (such as a subscriber name). Conversely, I could also indicate a point with my mouse and have the full related subscriber data pop up on the screen.

This is just a small example of how you can build and use custom applications with MapInfo. There are numerous variations, and one of the most interesting is thematic mapping. A thematic map displays some kind of data other than geographical locations. MapInfo can represent data themes using a variety of symbols, fill patterns, and colors. The photo shows a MapInfo map of Manhattan giving average household income in various locations around the city.

Once you've created a point file from your own data, you can use a variety of tools to turn a plain-vanilla map into a full-fledged, thematically based presentation graphic. The process is something between using a presentation graphics package and a desktop publishing package. (You can even design your own text fonts and icons or customize the ones that are already included.) But once again, MapInfo's steep learning curve comes into play.

A Resource-Intensive Program

With all the data it has to handle, MapInfo is a very disk- and processor-intensive program. It's especially strenuous on your system's hard disk drive. On my 10-MHz AT clone, I used it with both slow-access (65-millisecond) and fast-access (18-ms) hard disk drives. The difference in performance was very noticeable with the faster drive. On a 33-MHz machine with a fast hard disk drive, MapInfo flew.

MapInfo also uses any extended or expanded memory that it finds in your system. This speeds up the package's response time considerably. But I also found MapInfo to be more than a bit finicky. I used 2 megabytes of extended memory in my AT clone as a disk cache

continued

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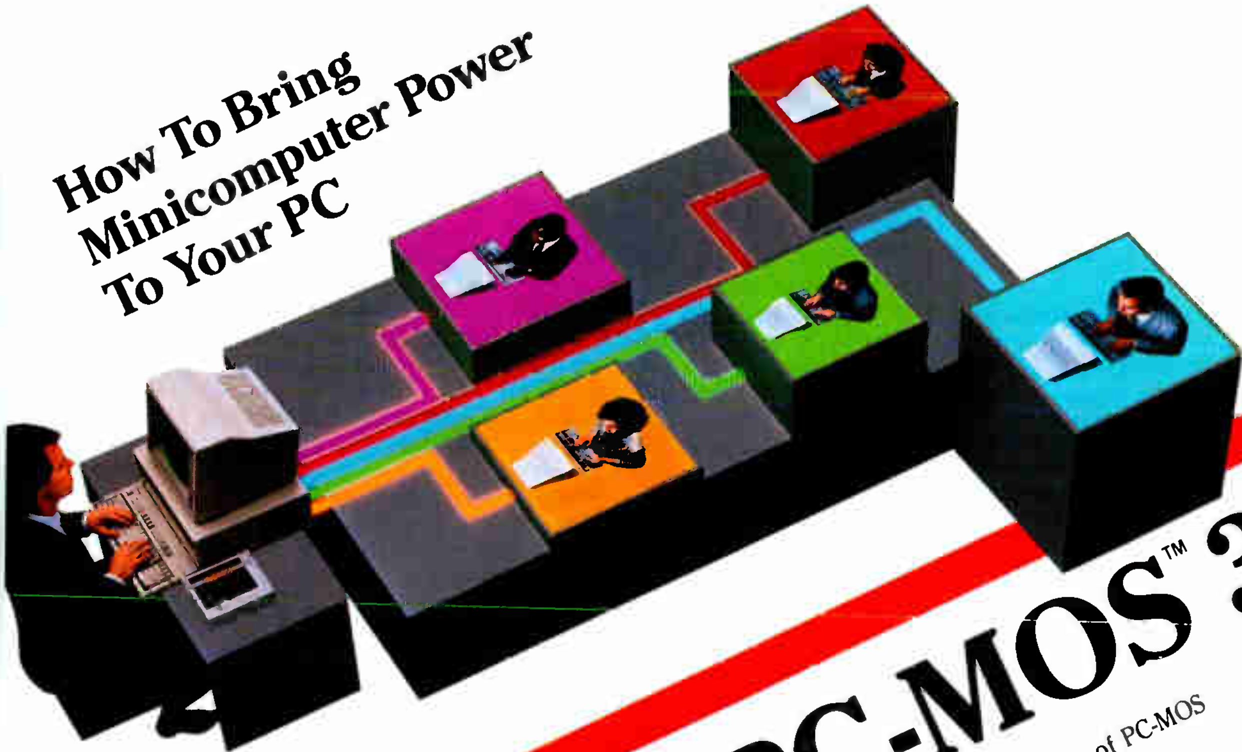

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controlled by Future Computing Systems' Fast, and MapInfo repeatedly locked up. When I turned off the cache, I had no problems.

MapInfo works with a wide variety of graphics hardware. Software drivers are included for everything from Hercules monochrome graphics through CGA (in black-and-white mode) all the way up to EGA and VGA. But although you can use it with older graphics standards, I found that VGA is really the only choice for serious MapInfo work. Additional drivers are available for the ultrahigh-resolution IBM 8514/A and other not-so-standard graphics adapters.

On the output side, printer drivers are included for industry-standard dot-matrix and laser printers, including PostScript devices. Since mapping applications lend themselves especially well to plotters, drivers are included for most popular pen plotters, including those from Houston Instrument, IBM, and Hewlett-Packard. Like the graphics drivers, MapInfo also has a wide range of additional printer and plotter drivers available at an extra charge.

The company has announced a network node pack ($595) that lets multiple users work on maps at the same time.

Following the Road Map

MapInfo is a unique and surprising package whose potential applications are limited only by the imagination. But like so many large applications, it is complex. One important difference between MapInfo and other applications is that it's virtually impossible to use just a part of it. To use MapInfo effectively, you must become familiar with the whole shooting match. That's not an easy job.

The program's designers could have made the learning process a bit simpler. There's no on-line help facility, and it's badly needed. In addition, MapInfo's user interface is quirky. Although some of the terms used in menus are initially daunting, they are necessary because of the singular nature of mapping concepts. However, main menus would be more useful if they dropped down instead of continually taking a large portion of the left side of the screen. (There's a full-screen option, but it's useful only for viewing a finished map.) A mouse isn't required for using MapInfo, but I found it a necessity for speeding up work.

The paradox of MapInfo is that the people who will find it the most useful are also the ones who are least likely to have the time and patience to live with its learning curve. A sales manager or city planner wants results immediately. Consequently, any office that's a serious MapInfo user will be better served by having one person who becomes the resident expert. For these real-world applications, MapInfo also sells MapCode ($395), a programming package and compiler that can be used to generate custom (and easier to use) MapInfo applications. It could be the logical solution to MapInfo's problem.

Still, if you're willing to get past the learning curve and other oddities, you'll find MapInfo one of the most useful applications around. Early versions have found a loyal following in various fields. MapInfo has the capability of turning graphical "what if" into "that's it." ■

Stan Miastkowski is a BYTE consulting editor, managing director of K+S Concepts (a documentation and consulting firm) and editor of the OS Report *newsletter. He can be reached on BIX as "stanm."*

Circle 267 on Reader Service Card

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The Pocket Ethernet Adapter is also an economical choice for a group of infrequent network users because it can be quickly and easily moved from computer to computer. It contains no configuration switches, completely avoiding the problems of address and interrupt conflicts common with other Ethernet adapters. Drivers for Novell Netware version 2.0 and 2.1 are included.

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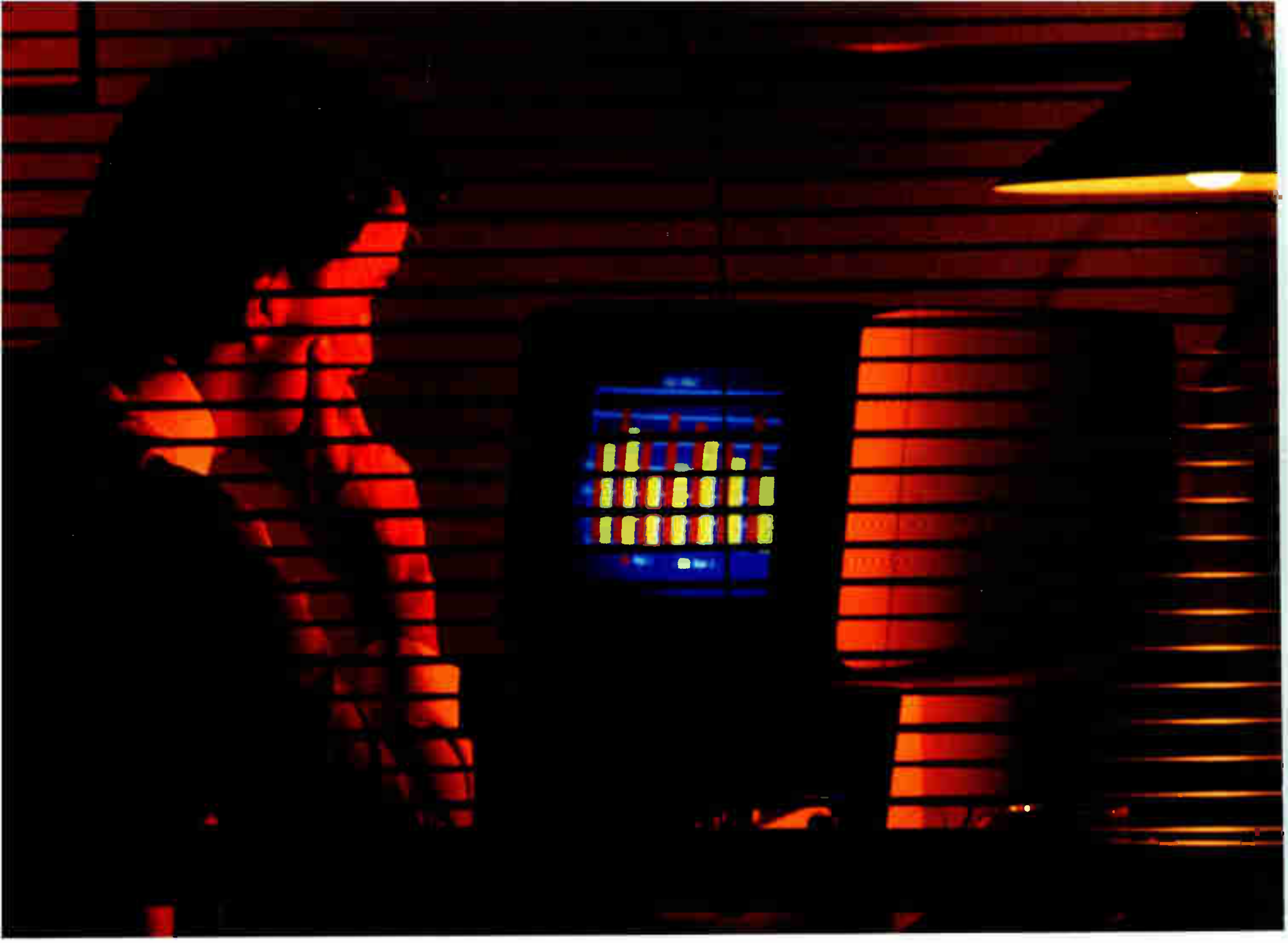

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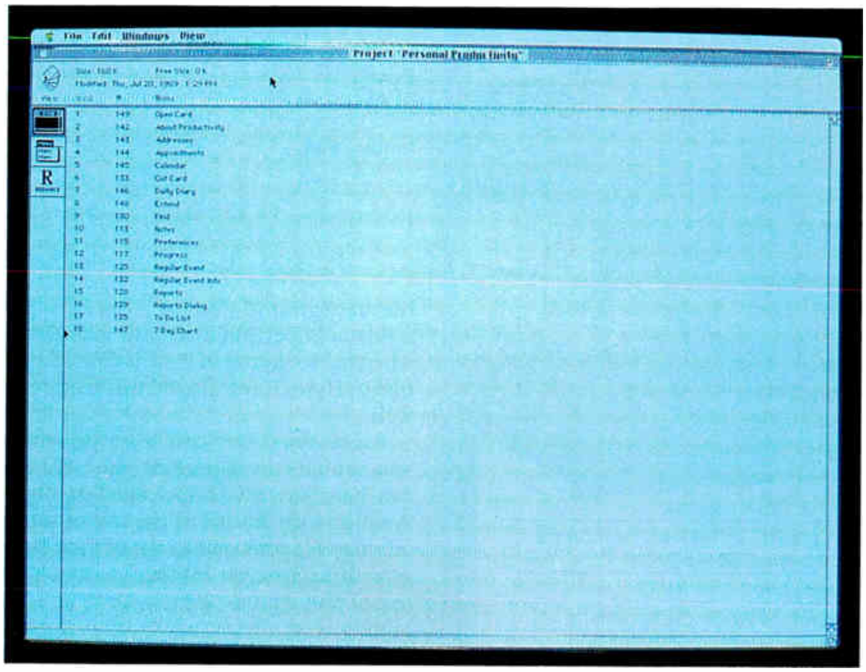
How Super Is SuperCard?

It has more features than HyperCard, but performance is slow

Richard D. Lasky



The user interface of SuperCard's SuperEdit is reminiscent of Apple's ResEdit.

It sounded too good to be true. Here was a program that took HyperCard as a starting point and added on a veritable wish list of features: color support, multiple windows, object-oriented graphics, irregular button shapes, and even the ability to create stand-alone applications.

That's what Silicon Beach promised of its SuperCard, and it does, in fact, deliver all those enhancements and then some. Unfortunately, those enhancements come at the expense of performance. The trade-off may be worthwhile for some people, and for others, SuperCard's bounty of features is at least worth considering.

Like HyperCard, Only Different

The basic file unit in SuperCard is a *project*, and each project contains at least one window. Windows can be any size, and SuperCard supports all the common Macintosh window types. A SuperCard window is the equivalent of a HyperCard stack. Each window has one or more backgrounds, and each background has at least one card.

Cards may be any size, unlike those of HyperCard, which are limited to only what fits into the 9-inch Macintosh display. In HyperCard, for example, you might have to divide a large map among several different cards. With SuperCard, the whole map is on a single large card that you can view through a scrolling window.

Another major difference between SuperCard and Apple's product is the way graphics are handled. HyperCard has just two graphics layers; both are paint-type bit maps. SuperCard supports both paint- and draw-type graphics, and each graphics image is treated as a separate object with its own properties and script. Also, instead of a Home card, SuperCard has a file called SharedFile to store common resources.

Two Programs in One

The SuperCard package actually consists of two applications, SuperEdit and SuperCard. You use SuperEdit to create new projects, and you use SuperCard to run them. SuperEdit's user interface is reminiscent of that of ResEdit, Apple's resource editing program (see photo).

Each project displays a list of the windows, menus, or resources contained in the project. The objects in the list are displayed by name, number, and ID number.

You can open any card in a window to get a visual display of the card's layout. Along the left side of the card layout window is a column of tool icons. You can toggle back and forth between card and background views.

Users familiar with HyperCard's treatment of background objects should be aware that SuperEdit handles things a bit differently. For example, in HyperCard's card view mode, you can move background buttons, but in SuperEdit—unless you explicitly select the background view—background objects remain inanimate. Although this takes getting used to, it's probably a good idea. I've often worked on a button or field in HyperCard and forgotten that it was in

continued

SuperCard 1.0

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San Diego, CA 92126
(619) 695-6956

Hardware Needed
Mac Plus or higher with two 800K-byte floppy disk drives or a hard disk drive; 2 megabytes of RAM is required for color

Software Needed
System 6.0 or higher

Documentation
User manual; language guide

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$199

Inquiry 886.

the background domain. Background fields in SuperEdit also have visible text when the background view is chosen, unlike in HyperCard. I liked this feature as well.

Every object can have a script, which you can edit in SuperEdit. In fact, you can have several scripts open at once. Another nice feature is the use of script editing aids provided in the editing window of each script. When you click on one of five buttons, a menu pops up containing all the reserved words in the SuperTalk language. For example, selecting `mouseUp` from the Sys Messages menu inserts the `on mouseUp...end mouseUp` message handler into the script window. The script-editing window is not modal, as it is in HyperCard. You have access to the menu bar as well as any other open windows, which I found very convenient and a big improvement over HyperCard.

You can also convert HyperCard stacks to new SuperCard projects using SuperEdit. It places the cards of the stack into a single window in the new project. (SuperEdit supports all the common button types found in HyperCard, and a few more to boot.) I converted two of my stacks. The first was a simple address-type stack of my customer base. This converted quite well and was fully functional (if a bit slower) in SuperCard. The second stack I converted was a demo version of a stack I developed for nutritional analysis. The calculations worked, but there was a major problem in the portion of the stack that created a bar graph. That's when I learned that I could not convert HyperCard's drawing commands to SuperCard without some modification.

SuperCard has some nice features that make work easy for the project designer. When you're working in the background mode, for example, choosing the `Gray Card` command from the view menu causes SuperEdit to display a grayed image of card objects behind the background objects that you are editing. This is a great help in aligning objects in the background mode with card objects.

The text field types are identical to those found in HyperCard. However, the opaque field type found in HyperCard is not available. Text within a field may contain several different fonts and styles, a significant feature lacking in HyperCard. However, a card with many font styles on it may take significantly longer to open.

SuperCard supports 8-bit color on the Macintosh II models. This requires at least 1.5 megabytes of RAM. A total of 256 colors (out of a possible 16.8 million) are available at one time. The available colors are contained in a resource called CLUT, which stands for "color lookup table." The system supplies a default CLUT, but you can create a new CLUT resource.

For graphics objects, you can set the "ink effects," which determine what happens to the bit pattern when one object is on top of another. Combining various ink effects with different fill patterns can yield some interesting visual effects. Seven ink effects are available for colored objects.

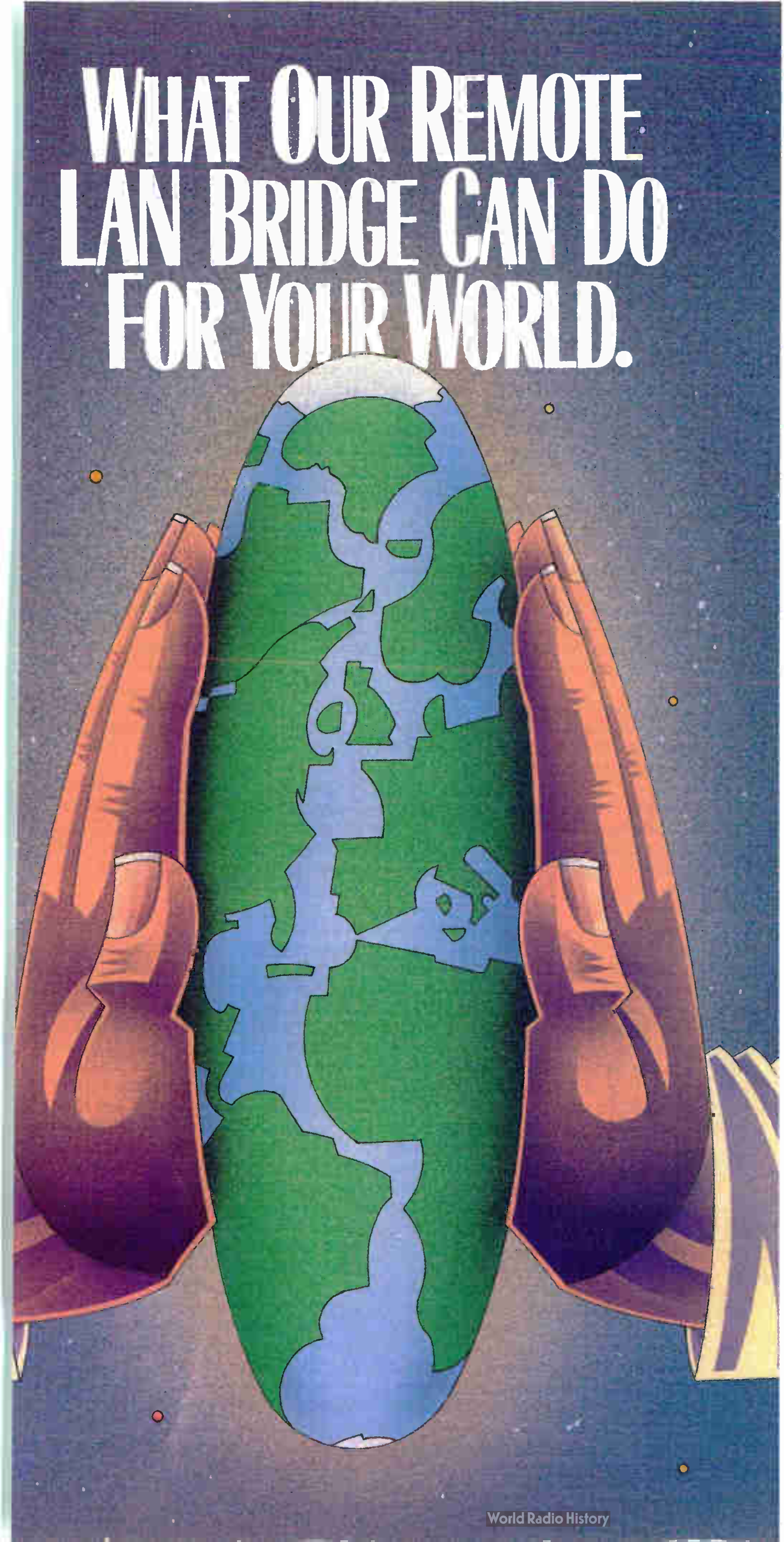
Unlike most applications, SuperCard stores resources in the data fork of the program. You can create three kinds of resources in SuperEdit: icons, cursors, and CLUTS. In addition, you can import sounds, XCMDs, and XFCNs (external commands and functions).

Running Projects

To run a project created with SuperEdit, you can go directly into SuperCard by choosing the `Run` command under the File menu in SuperEdit. When you subsequently quit SuperCard, you are returned to SuperEdit. However, this doesn't work when running MultiFinder; SuperCard dumps you back to the Finder instead.

SuperCard has some limited editing abilities that make it a useful environment for fine-tuning your project once it is near completion. You can create and alter objects and their scripts, but the

continued



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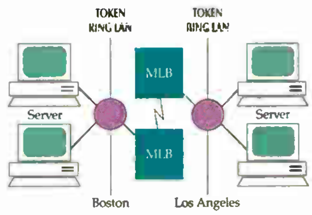

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program lacks any advanced editing features. For example, you can reshape a polygon in SuperCard, but if you want to change its ink effect, you must use SuperEdit.

Instead of simply having SuperCard run your project, you can convert your project into a stand-alone application. The advantage is that its distribution is not limited to those people who already use SuperCard. The other side of the coin is that creating a stand-alone application adds some 350K bytes of SuperCard run-time code to the size of the project file. The resulting application works just as if you were running the project with SuperCard; there is no noticeable gain in performance.

You can edit an application in SuperEdit, but you cannot convert it back into a SuperCard project. Unfortunately, SuperCard does not give you the opportunity to change the name of a project being converted. As a result, the new stand-alone file replaces the project file.

Frustrating Performance

I have two major complaints about SuperCard. The first is its memory requirements and poor handling in low-memory situations. Although the company advertises the minimum memory requirement as 700K bytes, my experience is that even 1 megabyte of RAM is insufficient for getting acceptable performance on a Mac Plus.

When I began reviewing SuperCard, I was chiefly working on a 1-megabyte Mac Plus. My attempts to use the program were fraught with frustration and frozen screens. Even when running one of the tutorial projects, I frequently got the "SuperCard is out of memory" dialog box. What made matters even worse was that half the time the system locked up as soon as I dismissed the warning message.

I upgraded my Mac to 2.5 megabytes of RAM. This let me experiment under MultiFinder. Both SuperCard and SuperEdit are initially set to hog 1600K bytes under MultiFinder, but these values can be reset from the Finder by using the `Get Info` menu command. I set SuperCard's partition for 750K bytes to test the company's claims of a 700K-byte requirement. I opened the "Ramblin' Ruth" project, a cute little tutorial project that comes with SuperCard. When I tried to add a simple menu to the menu bar, I got the familiar "out of memory" dialog box. I clicked "OK," and the screen froze.

Silicon Beach acknowledges that SuperCard has problems with low-memory situations. The company suggested removing my INIT files (such as QuicKeys and Suitcase) from my system folder to free up memory on my 1-megabyte Mac. But the company also agreed that it is unreasonable to expect Mac users to give up all their INIT utilities just to run SuperCard. (At least one INIT, called Boomerang, causes SuperCard to crash. It is the fault of Boomerang, and its author is correcting the problem.)

The other problem with SuperCard is the slowness of the screen refresh. This is most often experienced as a long delay going from card to card. Such a long pause would occur between the time I clicked the button and the time the screen auto-highlighted. Thinking nothing was happening, I would click the button a second or third time.

Even after upgrading my Mac to 2.5 megabytes of RAM, I found the response time unacceptably slow. For example, I compared HyperCard's Address stack and SuperCard's Productivity project—two Rolodex-like programs that let you "flip" through address cards. SuperCard took more than three times longer (nearly 3 seconds) than HyperCard just to go to the next card.

The company points out that SuperCard is not optimized for 342 by 512 bit-mapped cards, as HyperCard is. It suggests using STEP files for animation instead of flipping cards, and avoiding large bit-mapped graphics.

A Super Buy?

Before you rush out to buy SuperCard, carefully consider just what you expect to get. HyperCard users should bear in mind that many of the features in SuperCard are available as add-on XCMD or XFCN programs from third-party developers. For example, HyperWindows from Tulip Software ($59) lets you access multiple windows of any type from within HyperCard, and it also supports color displays.

The bottom line is that Silicon Beach has created a neat Mac erector set. SuperEdit has many exciting and powerful features, but you may be disappointed by SuperCard's slow performance. In addition, SuperCard is not appropriate for a Macintosh with only 1 megabyte of RAM. But if future versions of the program are better optimized for speedy performance, then SuperCard really will be a dream come true. ■

Richard D. Lasky is a biochemist and stackware developer living in Needham, Massachusetts. He can be reached on BIX c/o "editors."

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- Real Time Clock/Calendar with 5 Year Battery
- 80287, 80387 or Weitek Co-Processor Support
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- Medium foot print case with 5 Disk Drive bays

Options:

- 32KB or 64KB Cache Processor • Weitek Co-processor • Tower® Case
- Custom configurations w/Name Brand peripherals of your choice
- Compaq® Style LCD or Plasma Portable • 8MB 32Bit RAM Card

Standard Pre-Built Configurations:

386/25 With Hard Disk Drive, Monitor & Video Card

Video \ Drives	40MB-46MS 1:1MFM	66MB-25MS 1:1RLL	71MB-18MS 1:1 MFM	110MB-25MS 1:1RLL	150-17MS 1:1ESDI	320-16MS 1:1ESDI
Mono	$2312	$2462	$2592	$2722	$3322	$3572
VGA/Mono	$2527	$2677	$2807	$2937	$3537	$3787
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- 80387 or Weitek Co-Processor support
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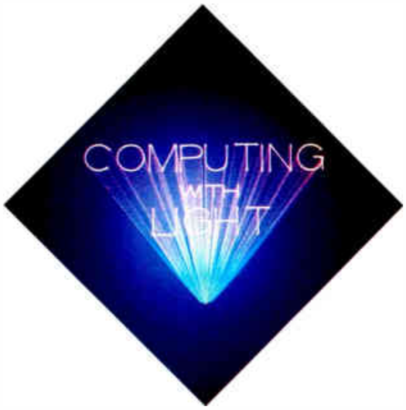

IN DEPTH

Optical Technologies

231 **Computing with Light**
by H. John Caulfield

239 **The Nitty Gritty Optical Band: Levels of Light**
by Joseph W. Goodman
Joining Forces
by Donald J. Channin

249 **Reflected Light**
by Gary T. Forrest

259 **Gigabytes On-Line**
by James J. Burke and Bob Ryan

266 **Read/Write Optical Subsystems**

The mystery of light has puzzled and intrigued man throughout the ages. Light forms the very basis of our existence. For the most part, living things, as evolved on this planet, need light to live. From the beginnings of recorded time, man held the sun, the visible source of light, in deep reverence. Whether you believe that ancient man worshipped the sun or that he worshipped the giver of light as represented by the sun, he obviously sensed his great dependence on light. Solar eclipses terrified him, simply because the light went away.

In our efforts to tame light and make it do our bidding, we have developed myriad light-generating and light-controlling devices from lamps to lasers. We may not fully understand the intricacies of light, but we have found many ways to use it. Today, lasers are stealing the headlines and the show.

This month, we focus on optical technologies and look at some of the ways in which laser light is affecting the computer industry. The concept of computing with nothing but light beams boggles the mind. In "Computing with Light," H. John Caulfield explains the concepts behind optical computing, as well as its limits as currently conceived: what it can and can't do. He also discusses holography and its uses in computers.

Next, a series article looks at the bits and pieces of optical technology that are beginning to come into being. "The Nitty Gritty Optical Band" looks at the inroads made in optical interconnections, packages, signals, and ICs. In the first part, "Levels of Light," Joseph W. Goodman discusses the various levels of interconnections, from the machine level to the on-chip level, and how well optics apply on each level. And in the second part, "Joining Forces," Donald J. Channin examines the marriage between electronics and optics down at the chip level and how this union delivers the best of both worlds.

Then, in "Reflected Light," Gary T. Forrest looks at lasers, the light that makes optics work. Laser technologies are in use for a variety of purposes, and different lasers have different uses. This article discusses the different lasers, how they work, and how they are used.

Although all these areas have elements of the present and the future in them, one optical technology we are all familiar with, if for entertainment only, is optical storage. In "Gigabytes On-Line," James J. Burke and Bob Ryan examine optical disks, from CD-ROMs to WORMs to erasable optical storage, and how they work. Our resource guide this month supports this article, listing sources for some of the read/write optical subsystems available.

Will optics replace electronics? Probably not, at least if present research findings continue to hold true. Will optics have a significant impact on our industry in years to come? Most resoundingly, yes! The advantages of optics over electronics in speed and freedom from interference alone are reason enough to fund its research. In more ways than one, lasers are indeed "the light at the end of the tunnel."

—Jane Morrill Tazelaar
Senior Technical Editor, In Depth

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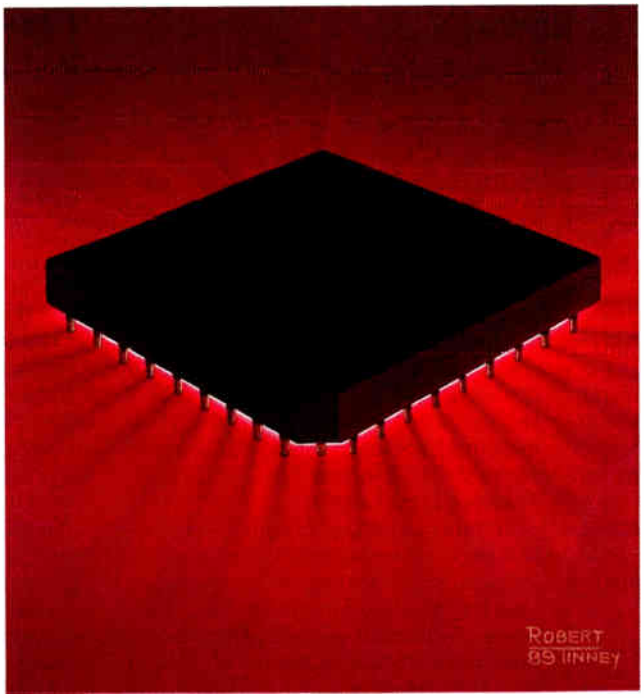
Computing with Light

Optical computers can provide the massively parallel architectures that systems of the next century will need

H. John Caulfield



The eternal search for faster, smaller, more intelligent processors is what drives the development of new technologies. For the past 40 years, advances in computers have depended on advances in electronics, particularly in semiconductor-based electronics. Computers of the next century, however, may require a technology that would seem as radical now as semiconductors were in 1964. Perhaps the Japanese Ministry of International Trade and Industry (MITI) put it best: "Electronics is the science of the twentieth century, and optics is the science of the twenty-first."

The state of optical technology in 1989 resembles that of electronic technology in 1949. It is poorly developed, unreliable, unstandardized, and expensive. Why, then, would you ever dream of replacing ICs with optics? Quite simply, you wouldn't. Optics are so fundamentally different from electronics that they do not compete. However, optics can do important tasks that are impossible with electronics. Using the special and wonderful properties of light, optics can work together with electronics in new hybrid systems that are called (somewhat misleadingly) *optical computers*.

Properties of Light

Light, like electricity, is a quantum phenomenon. As such, you can't really understand it, but you can write equations that will at least partially predict its behavior. Sometimes it's convenient to think of light as a stream of particles; light particles are called *photons* (electricity particles are called *electrons* or *holes*).

When the particle picture fails, you can think of light as a wave. In fact, depending on the experiment that you perform, light will demonstrate properties of either particles or waves, but not both at the same time. Of course, this doesn't exactly make sense, but this is what quantum mechanics tells us.

Although it may be impossible to understand the nature of light, you can—up to a point—get a handle on it mathematically. You can make essentially perfect predictions of average photon arrival rates and positions, but you'll still have no idea how to predict precisely when and where the next photon will arrive.

Photons belong to a class of particles called *bosons*. Bosons do not interact with other bosons. Thus, optical paths can crisscross in space without interfering with one another. Essentially all the strengths and weaknesses of optics come from this observation.

Electrons, on the other hand, are classed as *fermions*—particles that repel one another. Thus, electrons must be

continued

ILLUSTRATION: ROBERT TINNEY © 1989

A Trillion Points of Light

Creating a processor with fan-in and fan-out values of 1 million is possible only with optical computers.

The inputs to such a processor consist of the transmission values (0 to 1) of a 1000- by 1000-element holographic mask. The data is written in real time to a spatial light modulator (SLM)—the actual input device. The output of the processor is a 1000- by 1000-element detector array (see figure A).

The transmission of the k,l element of the SLM is called a_{kl}. Now, at the i,j detector element, you want to form

$$b_{ij} = \sum_{k,l} T_{ijkl}a_{kl}$$

where the sum b_{ij} is over all 1 million (10^6) SLM elements. You want to do this for all 10^6 i,j values. Thus, there will be a trillion (10^{12}) values of T_{ijkl} all in use at the same time. Figure A demonstrates how this is done for one of the b_{ij} patterns. It is important to note, however, that all 10^6 b_{ij} patterns appear simultaneously.

The i,j hologram produces a pattern of illumination at the SLM input. At the k,l SLM element, you refer to the input intensity as T_{ijkl}. The transmission value of that element is a_{kl}, so the amount of light passing through the k,l SLM element from the i,j hologram is $T_{ijkl}a_{kl}$. The imaging lenses to the left and right of the SLM project the laser light from the i,j hologram onto the i,j detector element. Since it does this for all k,l values, you detect the sum of all $T_{ijkl}a_{kl}$ products at every element of the detector.

All holograms and all detectors in this system work in parallel. Thus, the k,l SLM element has a 10^6 fan-in and a 10^6 fan-out. Furthermore, the optical paths clearly crisscross in space both before and after the SLM without interference. The results are 10^{12} parallel, weighted (i.e., different T_{ijkl} values) interconnections in a single optical processor.

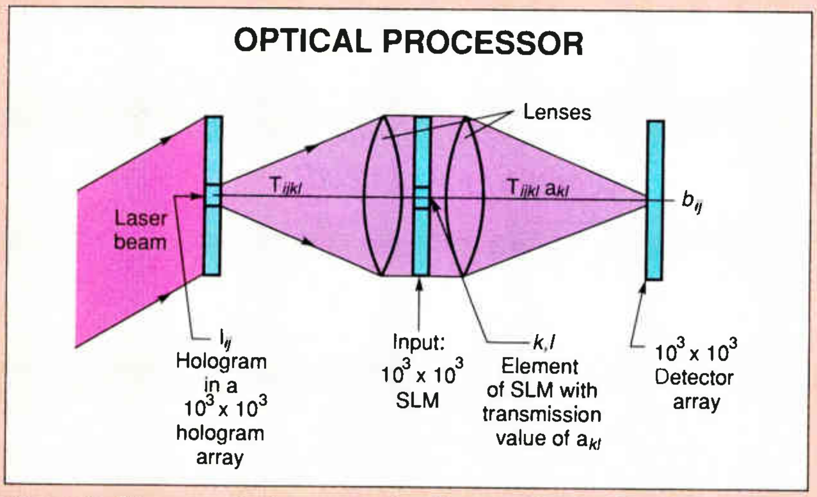


Figure A: *Shown are the interconnections for one of the 1 million* b_{ij} *patterns.*

confined in carriers (e.g., wires) to get them from one place to another reliably. These connecting carriers of electricity take up space that other carriers, therefore, cannot use.

Two conclusions follow immediately from these facts. First, optics is a wonderful way to provide large numbers of input connections (called a *fan-in*) and large numbers of output connections (called a *fan-out*) to a processor. Second, since light doesn't interact with light, you need electronics to get information on and off the beams of light.

Light Connections

To make a connection in electronics, you need a wire of some type and a bonding pad. To implement a fan-in and fan-out of 10 is no big trick, but larger numbers of connections are progressively harder to implement. With optics, you could have a million processors, each with a fan-in and fan-out of a million, all operating in parallel. You can't do this with electronics because of the pathways involved.

Imagine a million processing elements, each with 2 million bonding pads. The size of such an implementation would be absurd, as would be the power consumption, cost, and time required to solder the wires. The total number of connections in such a system would be 1 trillion. Electronically, this is silly to even think about. In optics, it is straightforward (see the text box "A Trillion Points of Light" above).

Another advantage of optics over electronics is that optics can operate at an average energy per calculation that is less than the theoretical minimum for a traditional electronic logic gate. Because the quantum mechanical nature of light is manifest when you don't confine it to a carrier (e.g., fiber-optic cable), you can make all intermediate calculations energetically free of charge and pay an energy price only for reading the final result.

For example, consider the optical calculation of b_{ij} discussed in the text box "A Trillion Points of Light." The calculation consists of 1 million multiplication operations and 1 million addition operations. When you detect the result and apply a threshold function to it, the quantity of information you extract is one bit: b_{ij} = 0 or 1. The atoms in the detector are moving with an average energy of kT, where k is the Boltzmann constant and T is the absolute temperature. Clearly, extracting information must require at least an energy of kT per bit. Indeed, kT is often considered the minimum "quantum of information."

To read out b_{ij} reliably, you must overcome "shot noise" by measuring many light particles or photons. For visible light and room temperature, the photon energy is about 100 kT. If you detect 100 photons, you spend about 10^4 kT to read out that one bit. The best low-power electronic computers operate at 10^4 kT per bit. Most operate at 10^7 kT or more.

But wait. You have measured the result of 10^6 calculations with 10^2 photons and only 10^{-2} kT per calculation. How is this possible? If you send even one photon to each of the 10^6 spatial light modulator (SLM) elements, you would need 10^6, not 10^2, photons. Or would you?

The answer to this lies in quantum

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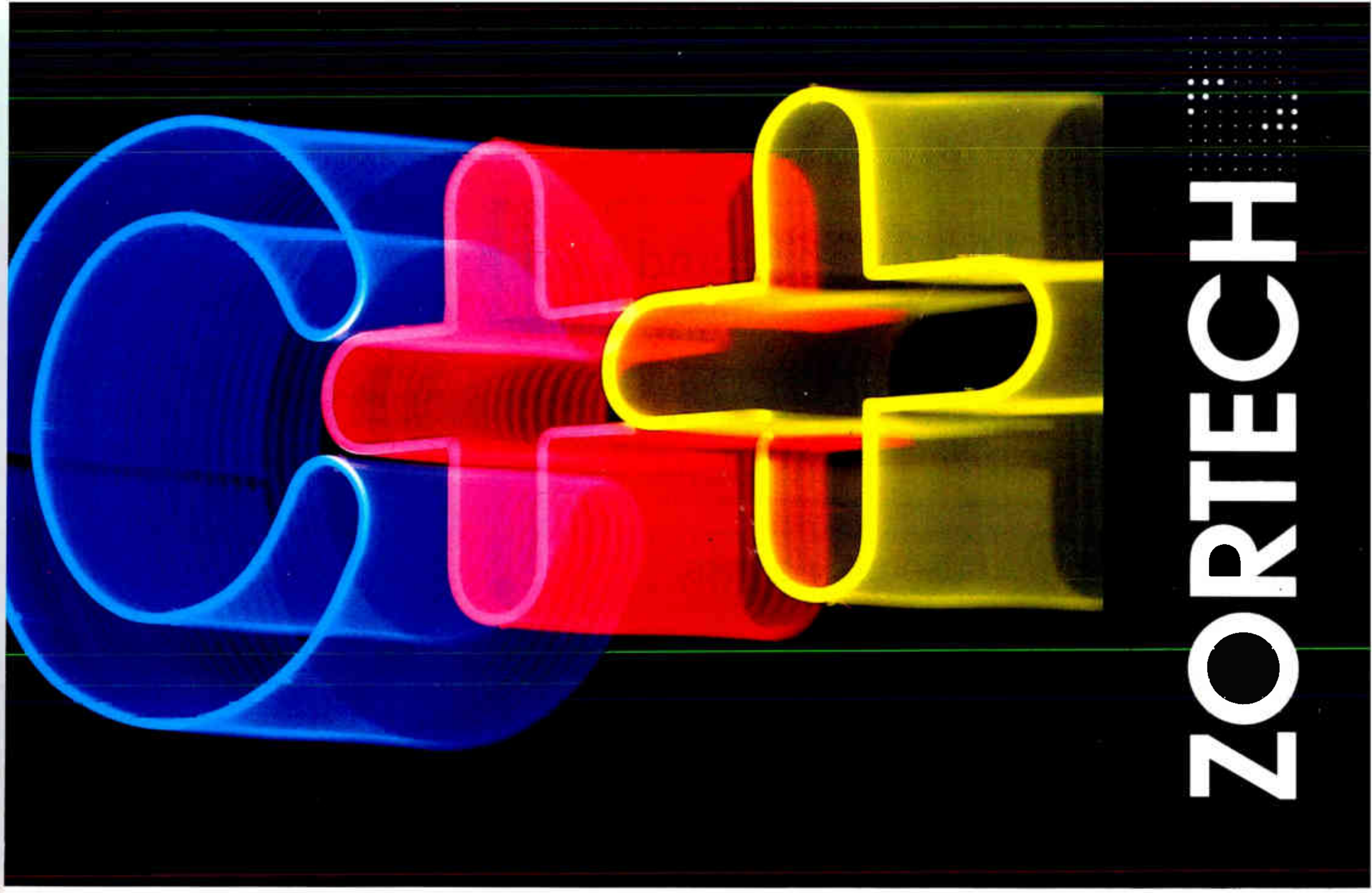

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Holography and Computers

Holograms have become a common sight. They appear on credit cards, paperback books, greeting cards, camera boxes, children's toys, and even magazine covers. Soon you'll be seeing them on your windshield as they let you check your speedometer without taking your eyes off the road. So just what are holograms, and how do they relate to optical computers?

Before answering these questions, consider another one: How is it that light entering the pupils of your eyes and crudely focused on your retina causes you to see a multicolored, three-dimensional world "out there" and not in your head? While no one can answer this basic question, the fact that you do see "out there" is critical to holography.

What you see is not a direct result of the scene you're viewing, but of the pattern of light the scene creates on your retina. Thus, you don't have to re-create the three-dimensional world in order to re-create a scene; all you need to do is cause the same pattern of light to enter your pupils. You don't need the real world at all—just a way of reconstructing the desired light pattern or *wavefront*.

Holography is a two-step process: wavefront recording and wavefront reconstruction. To reconstruct a pattern of light, you need a source of light. Consider the two wavefronts shown in figure B1. The object wavefront created by the object and the reference wavefront form an interference pattern, which can be recorded on a photographic plate. This recording is the hologram.

The hologram is a transducer from the simple, readily reproduced reference wavefront to the complex object wavefront. The hologram literally selects out of the reference wavefront the portion that looks like the object wavefront (see figure B2). The human eye intercepts this wavefront and sees the original scene behind the hologram.

The light doesn't actually come from where you see the image. This is a *virtual image*, just like the image in a mirror. But, by perfectly reversing the reference wavefront, you can perfectly reverse the object wavefront. Viewable from beyond the object position is an image of the object. This time, the light really does come from where you see the image. This is a *real image*.

This two-step recording and recon-

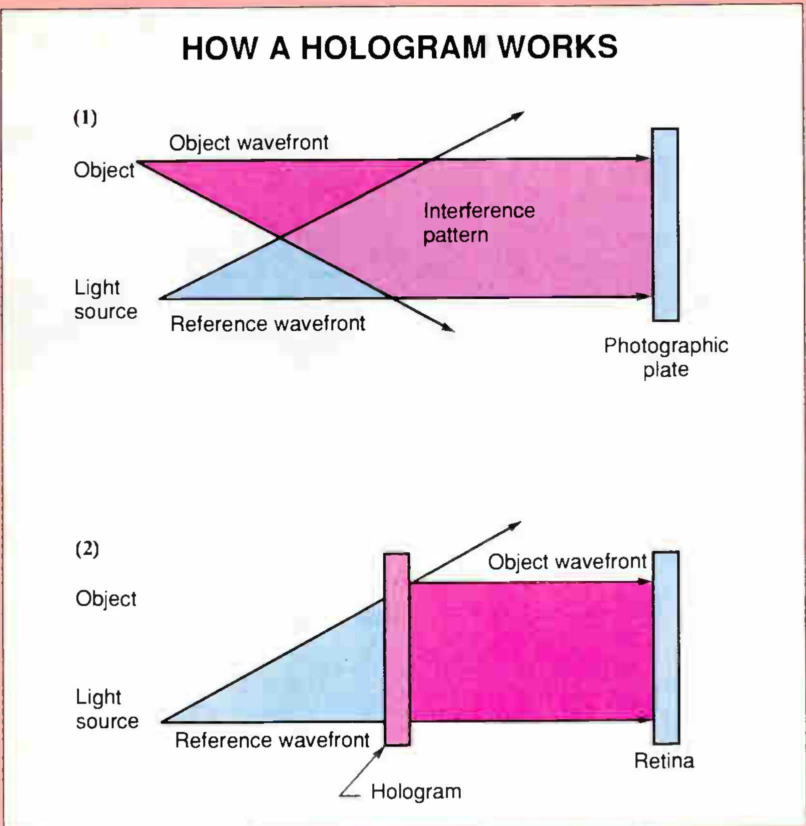

Figure B: (1) *The interference between the reference wavefront and the object wavefront creates the hologram.* **(2)** *The hologram reconstructs the object wavefront from the reference wavefront.*

mechanics. Each photon explores all 10^6 paths. In the wave domain, the light has no one path. Each photon, in effect, makes all 10^6 calculations! As long as you don't collapse the wave function by asking for the results of intermediate calculations, you can make the intermediate calculations without energy costs.

The average energy per calculation for a complicated calculation is therefore much less than the theoretical minimum for a logic gate. That theoretical minimum, in turn, is much less than the actual energy loss in even the most efficient logic gates.

Due to these properties of light, optical computers can feature massive parallel interconnections that are impossible physically and energetically with electronic computers. A representation of a generic optical computer is shown in figure 1.

Optical Components

The key component of an optical computer is the SLM. It is a discrete or continuous array of light modulators whose reflection or transmission properties can be controlled electronically or optically. This page is an SLM. It reflectively modulates incident light in a spatial pattern. It is not a very useful SLM (at least not for optical computing), because you can't change the reflectivity pattern rapidly. Useful SLMs are changeable by either optical or electrical addressing.

About 25 different SLMs are available commercially (see table 1). SLMs are used as input devices, interconnection devices, scratch-pad memory devices, and processing devices. They are vital to optical computing.

The second most important component of an optical system is a hologram, which provides interconnections as well struction concept was proposed by Denis Gabor in 1947, winning him a Nobel prize. The technique most used today was invented in the early 1960s by Emmett Leith and Juris Upatnieks. In this recording technique, both wavefronts are derived from a single laser beam split into two beams by a partially reflective, partially transmissive mirror. If you observe several simple precautions, the two beams form an interference pattern where they overlap. That is, where the two beams agree (i.e., are in phase), the light is bright (constructive interference). Where the two beams disagree (i.e., are out of phase), the light becomes dim (destructive interference).

By recording a photographic positive of the interference pattern, you produce exactly the hologram you want. This hologram will pass from the reference wavefront only those parts that could just as easily have come from the object wavefront.

Holography at Work

A hologram is the most versatile of optical elements—it can produce essentially any light pattern you choose. For example, suppose you have a two-dimensional array of small (1 to 2 millimeters) holograms on a single substrate. When illuminated at normal incidence with a collimated reference beam, each hologram can produce a real, two-dimensional image on a fixed output plane. By deflecting the laser beam to the proper hologram, you direct the corresponding "page" of data to the output plane. This is called a page-oriented holographic memory, or POHM (see figure C).

You can store from 10^4 to 10^6 holograms in a POHM, with each output image containing from 10^4 to 10^6 binary bits. Thus, up to a gigabit of memory can be randomly accessed in the time it takes to deflect the beam (normally about a microsecond). This means you can access a gigabit of memory randomly at a rate of from 10^{14} to 10^{18} bits per second! That's serious RAM.

Work at the Georgia Institute of Technology and the Center for Applied Optics at the University of Alabama, Huntsville, is leading to compact, high-density POHMs with a parallel, optically addressable RAM in the output plane. If the output plane contains an optically addressable spatial light modulator (SLM), you can write the whole page onto a laser beam in parallel. Using a modification of the Fourier optical pattern recognizer, you can search that page in parallel for key words. This forms the basis for an optical DBMS that operates on 100,000 bytes at a time. This is a considerable advantage for large databases.

Perhaps the most dramatic application of holography to optical computing is in neural networks. There are two distinctly different research approaches in this area. One exciting possibility is to make a "live" hologram that can continue to learn as it experiences its world. Although this area is quite complex and long-range, considerable advances have been made at Hughes Aerospace, California Institute of Technology, the University of Colorado, and elsewhere. A simpler and perhaps more desirable goal is to use holograms to build neural networks that employ fixed learning.

Even the lenses in optical computers are likely to be computer-generated holograms. They are far lighter and far cheaper than glass lenses and can be computer-optimized to outperform ordinary lenses. This work, pioneered at MIT's Lincoln Laboratory, is now being actively and widely developed.

Holograms are not only items of great wonder and beauty; they are also items of great practical utility in optical computing. They provide the type of storage required by massively parallel optical computing systems.

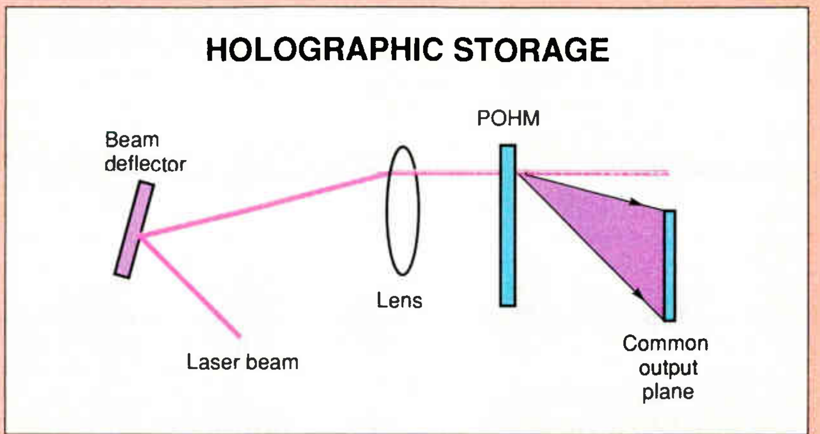

Figure C: *Retrieving information from page-oriented holographic memory (POHM) involves deflecting the output of the read beam onto an output plane.*

as memory capabilities. The text box "Holography and Computers" above discusses holograms in depth.

Optical Computations

Although optics is ideal for connections and storage, it is not well suited for computation. In fact, the best you can get from purely optical operations is about a 10 percent accuracy rate. This is the downside of optical computing and the reason that purely optical computers are not a realistic possibility. Hybrid electro-optical computers, however, are another story.

Many types of computations require some sort of nonlinear processing where the output signal intensity, I_O, is related to the input signal intensity, I_I, by a function like the ones shown in figure 2. The operation of all the functions in figure 2 can be performed "optically." (Since light does not operate on light, some hidden or covert electronic manipulation must also be going on within the device or system.)

There is a great deal of worldwide research into the design and construction of two-dimensional arrays of nonlinear optical operators. Of the many diverse approaches being investigated, most involve highly nonlinear feedback arrangements that lead to what mathematicians call *catastrophes*. Here, you create a device whose transmission increases nonlinearly with the incident light intensity. In addition, you couple some of the transmitted light back as input. This combination leads to the sudden onset of high transmission that the representative curves in figure 2 illustrate. Perhaps the most promising research on these nonlinear optical devices is being conducted at Bell Laboratories.

continued

Optical Research

Optical computers must emphasize the strong points of optical technology (e.g., interconnections and low energy) while tolerating or minimizing the bad points (mainly, low analog accuracy). At universities such as Carnegie Mellon, the University of Iowa, and the University of Alabama in Huntsville, the focus of research is on computers that marry a fast, low-accuracy optical processor (for computationally complex tasks) with a slower, higher-accuracy, digital part (to "ratchet" the accuracy). These machines are suited to problems such as algebraic equations (linear and nonlinear), eigenvector problems, matrix inversion, and heuristic linear programming.

Table 1: *This shows the range of properties of commercially available spatial light modulators. Unfortunately, no single SLM combines all these features.*

Characteristics of spatial light modulators

Mode: Reflection, transmission
Addressing: Optical, electronic
Cost: $100 to $50,000
Information: 64 by 64 elements to 25,000 by 25,000 elements
Cycle time: 10^{-6} seconds to 1 second
Contrast: 2-to-1 to 10^4-to-1
Resolution: 0.002 cm to 0.10 cm
Pattern: Discretized, continuous

For example, consider the simple analog optical multiplier shown in figure 3, which performs a parallel multiplication of an input vector with a matrix. You want to find **x** such that

$$A\mathbf{x}=\mathbf{b}$$

where **b** is a given vector and A is a given matrix.

You can solve this problem crudely in parallel by adjusting x_1 in proportion to y_1-b_1, x_2 in proportion to y_2-b_2, and so on, all at the same time. With proper precautions, you can assure that **x** will relax continuously to the point where for all i, $|b_i-y_i| < \epsilon$, where ϵ is a small positive number.

Now, you read out this analog **x**, digitize it to the accuracy you need for the final result, and call it $\mathbf{x}_0$. You can now evaluate the residual

$$\mathbf{r}_0=\mathbf{b}-A\mathbf{x}_0$$

digitally. If the norm (usually Euclidian) of $\mathbf{r}_0$ is written $||\mathbf{r}_0||$ and if $||\mathbf{r}_0||$ is suitably small, you quit and output $\mathbf{x}_0$. If not, you solve the problem

$$A\Delta\mathbf{x}_0=\mathbf{r}_0$$

optically, then digitize the result, and then calculate

$$\mathbf{x}_1=\mathbf{x}_0+\Delta\mathbf{x}_0$$

and

$$||\mathbf{r}_1||=||\mathbf{b}-A\mathbf{x}_1||$$

digitally. You continue until you achieve the desired accuracy.

This approach fails for hard (ill-conditioned or singular) problems. To achieve guaranteed results, you must replace the given matrix A by a noisy version, A+N, during the optical operations. The system then achieves the desired minimum $||\mathbf{r}||$ for all matrices. In addition, the time taken is independent of the problem size. Both of these features (guaranteed convergence and speed that is independent of problem size) are apparently unique to this bimodal optical computer.

You can also do general-purpose digital computing with optics. One promising approach, symbolic substitution, is being pursued at Bell Laboratories. Another approach, the operator method, is being developed at Opticomp. It amounts to a highly parallel programmable logic array that doesn't need to distinguish among multiple signal levels. It simply makes a light or no-light decision. Even at optical accuracy, this is not hard.

A large number of special-purpose optical computers use Fourier transforms to locate and identify objects in a scene. The systems depend on the fact that two successive Fourier transforms produce an image of the input (albeit upside-down and backward). First, you use a lens to form a two-dimensional display of the Fourier transform of an input pattern.

The interesting thing about the Fourier transform pattern is that its shape and location don't change as you move the input around. If you place a filter in the Fourier transform plane that favors the transform of A and tends to block the

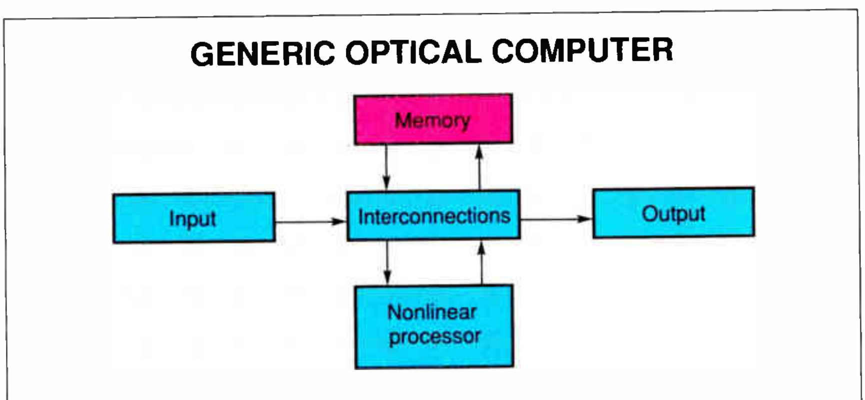

Figure 1: *Holograms provide memory storage and interconnections, while spatial light modulators are commonly used for input, output, and processing units.*

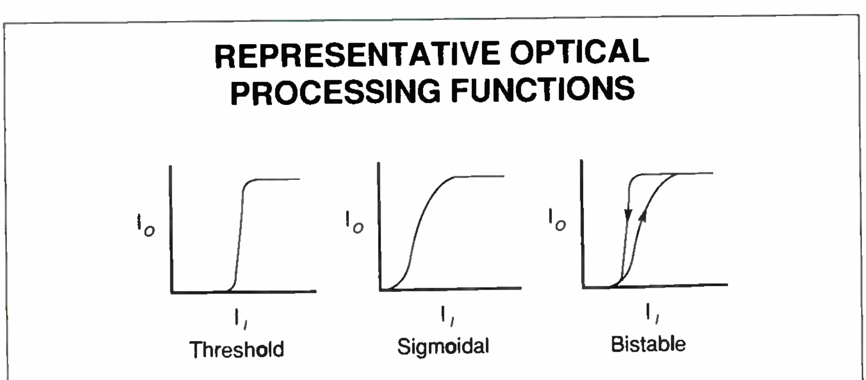

Figure 2: *These functions represent the type easily implemented on optical processors, where I_i is the input signal intensity and I_o is the output signal intensity.*

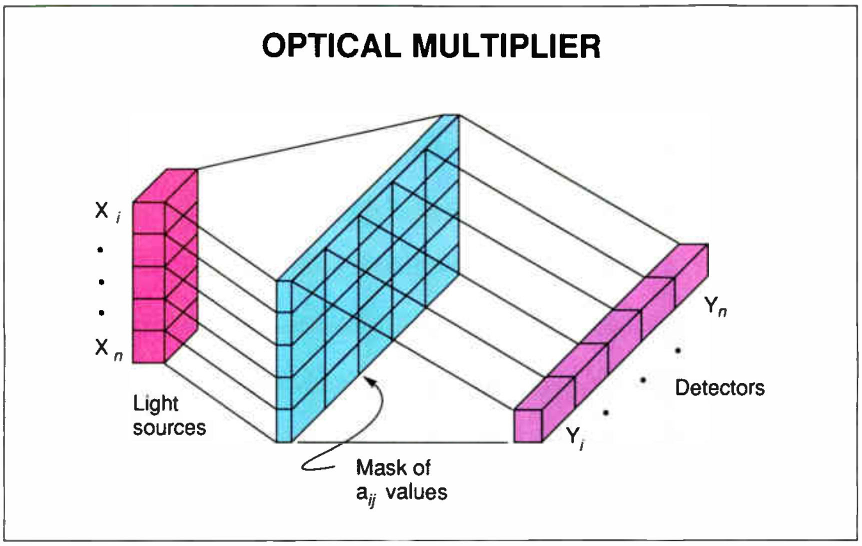

Figure 3: *This analog optical multiplier evaluates the expression* **y** = *A***x**.

transform of B, you will distort both images, but there will be much more light in the blurred A image than in the blurred B image. You use this difference to identify and locate objects in a scene.

Optics and Neural Networks

Of all the optical computing paradigms, the one that uses the interconnection and energy advantages of optics best is neural networks. (For more information on neural networks, see the In Depth section, August BYTE.)

Neural networks are attempts to build processors that work like the human brain. (Digital computers are not much like the brain.) You don't program a neural network; you train it to connect a certain output with a certain input. Unlike the deterministic, discrete, linear logic of digital computers, neural networks display traits like inference and intuition.

Neural networks use processing elements called *neurons*. These are found in layers and are connected to many neurons in both the layer above and the layer below. Thus, neural networks depend on large numbers of interconnections.

If you have n neurons in a layer of a fully connected neural network, each input neuron has a fan-out of n differently weighted interconnections, and each output neuron has a fan-in of n differently weighted neurons. When n approaches 30 or 40, for example, these fan-ins and fan-outs strain the capabilities of electronics. Biological neurons can have much higher fan-in and fan-out, about 10,000. With holography, you can connect a million neurons to each other in parallel with independently chosen weights. That's an incredible 1 trillion independent, parallel interconnections.

Although neural networks are unlike digital computers, most current implementations are actually software simulations running on digital computers. Analog-electronic and optical neural networks will likely prove far more useful than these simulations in the future.

Some optical neural networks combine the learning and reaction in the same hardware like the brain does. These can be very powerful, but they are also very difficult to make. Other optical neural networks do the learning off-line in a digital computer and embody what is learned in a fixed hologram. These are simpler and therefore likely to be useful sooner.

Don't Throw Away Your Micro

These are but a few examples of optical computing. There are many more, with many applications of each.

Optical computers will add to, rather than replace, your microcomputer. The new applications they engender will affect your daily life early in the next century as the Information Age unfolds. ■

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Circle 70 on Reader Service Card

The Nitty Gritty Optical Band

Optical packaging, interconnections, ICs, and signaling

Right now, we are bumping against the edges of the capabilities of electronics. We need to go beyond our electronic domain into a world that is faster, more secure, more parallel, and more densely interconnected but has less interference. Photonics has significant strengths in these areas.

Optical technology can help pull us into the next generation of computing. It is more secure than electronics: Generally, optical communications don't suffer from crosstalk. It is faster: Light travels faster than electricity and isn't constrained by factors, such as capacitance, that slow down signals in conductors. It is more parallel: Since thousands of dedicated light beams can simultaneously travel through a lens, an optical device can accept multiple inputs at the same time. And it provides advantages for interconnections because light rays do not interfere with each other.

Optoelectronics

Between the optical and nonoptical environments exists a hybrid domain called optoelectronics with one foot in electronics and the other in photonics. The combination of these two technologies brings us advantages and performance capabilities that are not possible with either of them alone.

Here are some possible applications of new optoelectronic techniques: optical communications networks that rapidly transmit signals around the world and into outer space; optical ICs that promise to be able to combine serial and parallel processing in a three-dimensional computer that can handle massive AI applications; and optical computers and other devices that can perform a thousand times faster than today's supercomputers.

These devices can take different forms: computers that think like we believe humans do, for example, and optical data storage disks that can hold orders of magnitude more information than their magnetic counterparts. In addition, other kinds of devices can easily and rapidly outperform current systems in areas such as pattern recognition, image processing, communications signal processing, voice recognition, and matrix manipulation.

Essential Elements

Domains like optical packaging, interconnections, ICs, and signaling are key to the future of computing. The technologies are essential elements in the progress of the overall optical environment.

Optical packaging encompasses the issues surrounding the various combinations of components on chips and boards and their interconnections and integration. Generally speaking, the major

continued

components all optical systems share are the transmitter, the receiver, and the medium. Overall, the aim is to embed more fundamental electronic functions into the light transmitter and receiver modules to create smaller packages that are easier to implement and use.

Packaging priorities are usually application-specific. The connection between the various components is a prime factor in whether or not the packaging is successful for that particular application. A recent development in *pigtail* technology has eliminated some of the interconnection problems in the packaging area. A pigtail is the optical fiber that is permanently attached to the active area of the LED or laser.

Cost is a constraining issue in optical packaging. Components and connections are still much more expensive than their electronic counterparts. But with improvements in, and wider use of, molded plastic optical elements (one of the developments that will make optical techniques viable), the economics of optical technology are gradually migrating into the range of affordability.

New Directions

Years of research are now paying off, and scientists in the areas of semiconductor, circuit, switching, and holographic technologies are beginning to see some outstanding results. These potentially viable results include the use of materials such as gallium arsenide, copper chloride, indium antimonide, zinc selenide, and multiple quantum wells for semiconductors.

A new technology called optoelectronic integrated circuit (OEIC) uses elements such as diode lasers and optical photodetectors fabricated on the same chips that contain electronic circuit functions.

Self electro-optic effect devices (SEED) and quantum-well devices are being considered for switches. In addition, earlier this year, scientists at British Telecom's Research Laboratories achieved the first complete optical self-switching of ultrashort light pulses, known as *solitons*. The success of this process promises that optical fibers will play a major role in fundamental optical-processing elements of the future.

Holography is the basis not only for optical computing, but also for other applications such as storage using optical associative memory. Other interesting experiments are being carried out on holographic look-up tables in the digital optical-computing domain, holographic interconnections, architectures employing real-time holography media (e.g., photorefractive materials), holograms as a technique for connecting the neurons in a neural network, and even holograms as communications links.

Optical devices and components have improved tremendously, as has the fiber we use as a medium. Researchers believe photonics will be of use in the AI field in the areas of optical database and knowledge-based machines, perception, and learning. Optical technology also appears to have a significant role in the emergence of neural networks.

Optical architectures useful for processing two-dimensional signals using acousto-optic (AO) devices have been developed and demonstrated for several applications. AO devices are one-dimensional spatial light modulators (SLMs). The areas of architectural considerations and scaling of algorithms and computation for the optical computing environment are also being studied.

Still a Few Years Away

When will we see an optical computer? Some working models already exist in today's research environments. At least one company has a digital optical computer up and running, and another firm has one on the drawing board, but a commercial model of an optical computer is still a few years away. In the meantime, better optical communications, optical storage, and optical displays and many optical techniques are already being incorporated into existing systems.

—Janet J. Barron
Technical Editor

Levels of Light

Are photons inherently superior to electrons in providing interconnections?

Joseph W. Goodman

On a fundamental level, a digital computer consists of a collection of nonlinear elements (the *gates*) within which signals interact, and interconnections among these elements or among groups of these elements. While attention most often focuses on the gates and their properties (e.g., switching speed and power dissipation), the interconnections are no less important. In fact, as the speed of transistors on chips increases, the interconnections become the limiting factor in overall chip performance.

Interconnections appear within a computer not only between gates at the chip level, but also at many other levels of an entire interconnect hierarchy:

Level 1: Machine-to-machine interconnections. Examples of interconnections at this level include the coaxial electrical cable of Ethernet, which transmits data at a rate of 10 million bps, and the optical fiber of the Fiber Distributed Data Interface (FDDI), which will soon replace Ethernet in many high-speed applications, at a data rate of 100 million bps.

Level 2: Module-to-module interconnections within a single computer, where a module may consist of a unit of memory or a processor. With the increasing emphasis on multiprocessor computers as an architecture of choice, these interconnections are becoming more important.

Level 3: Backplane-to-backplane interconnections. Large computers typically consist of a multitude of backplanes into which electronic boards are inserted. These backplanes must exchange information, and therefore must be interconnected.

Level 4: Board-to-board interconnections on a backplane. The backplane supplies the bus or communications channel through which the boards communicate.

Level 5: Chip-to-chip interconnections on a board. A typical printed circuit board may contain a hundred or more chips. Data usually flows between these chips via metallic lines embedded in the board.

Level 6: Gate-to-gate interconnections on a single chip, representing the lowest level of the interconnect hierarchy. Interconnections at the chip level are part of the chip design and are typically achieved through extremely fine lines of polysilicon or metal fabricated on the chip itself.

Photons vs. Electrons

Physically, there is reason to believe that photons are inherently superior to electrons in providing interconnections. Electrons are charged particles and therefore influence one another through the forces that electrical fields exert. On the other hand, a photon carries no charge and therefore exerts no influence on other photons. Thus, optical beams in a linear medium pass through one another without interaction, an attribute that is ideal for interconnections.

As the speeds of electronic circuits increase, greater and greater difficulties are encountered in providing the required interconnections at all levels. Photonics has come to the rescue at level 1 of the hierarchy, with many large computer companies accepting the new FDDI standard; the prospect of a tenfold improvement over Ethernet speeds in the near future is now a certainty.

The success of photonics in interconnections stems from the low attenuation of optical fiber, which allows using long spans of fibers without repeaters, and the freedom of optical signals from electromagnetic interference. Equally important are the extremely high data transmission rates possible in optics. These rates are often limited not by the fiber itself, but by the electronic devices that convert electrons to photons at the optical transmitting end and photons back to electrons at the receiving end. The inherent bandwidth of the best fiber is sufficient in principle to allow digital data transmission at rates greater than 10 *trillion* bps, if only we could access that bandwidth through suitable optoelectronic devices.

A photonic interconnection requires converting electronic signals flowing on wires to optical signals flowing on an optical channel. Electronic signals are most commonly converted to optical form with LEDs or semiconductor laser diodes, the latter being more efficient than LEDs but also having poorer reliability. Unfortunately, no efficient and practical method exists for generating light using silicon as the device material; virtually all semiconductor optical sources are based on gallium arsenide (GaAs) technology or its relatives. Photodetectors perform the actual conversion of optical signals to electronic form. Both silicon and GaAs make efficient detectors. Each of the conversion steps has less than perfect efficiency, but the detection step is generally far more efficient than the light-generation step.

Optical fibers provide the most widely recognized medium for transporting optical signals. However, when the interconnect distances are short, as they are within a single computer, other possibilities exist. You can construct optical waveguides in planar form on silicon or GaAs chips, and use them to carry optical signals at level 6 (gate to gate) of the hierarchy. Other types of optical waveguides can be fabricated at level 5 (chip to chip). You can also use holographic optical elements to transmit or reflect light to a prescribed set of locations, thereby creating a *free-space* optical channel. Each approach has its own particular strengths, with fibers generally being preferred at the higher levels of the hierarchy, and waveguides or possibly free-space interconnections at the lower levels.

The use of photonics to provide the highest-level interconnections (i.e., between computers, or between computers and high-speed peripherals) is already a proven technology, although many improvements are possible. At the opposite extreme, photonics is unlikely to provide a viable interconnect technology at level 6 (gate to gate), the lowest level of the hierarchy. The reason is complex, but to put it simply, the power efficiency of a photonic interconnection compares favorably with that of an electronic interconnection at the machine-to-machine level; however, the photonic solution compares unfavorably with the electronic solution at the gate-to-gate level.

On the Level

Connecting computers with optical fiber (level 1) is the purpose of the new FDDI standard. It is a proven technology.

One of the earliest examples of the use of photonic interconnections *within* a computer is the so-called Dialog.H computer constructed at the Electrotechnical Laboratory in Tsukuba, Japan (which is funded by the Japanese Ministry of International Trade and Industry). This computer consists of a multitude of electronic processors (level 2), each having its own local memory. The processors are arranged like the spokes of a wheel around a central hub (see figure 1).

Each processor has an optical source and a photodetector. When one processor wishes to communicate with another, it broadcasts an optical signal through free space toward a convex mirror located at the hub of the wheel. The mirror spreads the light so that a portion of it falls on the photodetectors of all processors. Each message contains a header indicating its intended destination. Only the proper destination accepts the message, and when it does, another processor can use the optical channel. Thus, a time-shared communications bus is realized within the computer.

A second early example is the 5-ESS switching computer made by AT&T. This type of computer supplies, at many locations through the communications network in the U.S., the computational power needed to route messages to their proper destinations. The 5-ESS computer uses photonics and optical fibers to supply interconnections between its several backplanes (level 3). Optics was chosen for this task because of its ability to eliminate troublesome *ground loops*, or unwanted stray electrical paths that plague large electronic systems.

Several industrial organizations have active research projects investigating the use of optics for interconnecting multiple electronic boards (level 4). The so-called *optical backplane* must be capable of providing data rates in the range of 1 Gbps to 10 Gbps (1 gigabit per second = 1000 million bits per second) or higher.

Both industrial research laboratories and universities are investigating the use of optics at the lower levels of the interconnect hierarchy, including chip-to-chip interconnections on a board (level 5). Several U.S. companies, including Honeywell, Rockwell, and IBM, have significant development efforts to provide multi-Gbps optical channels into and out of GaAs chips. Many Japanese companies have similar efforts.

The one intrachip (level 6) interconnection where optics may provide a viable alternative to electronics is in clock distribution. Virtually all electronic chips must widely distribute a synchronizing signal called the clock, which serves as a time reference for the many

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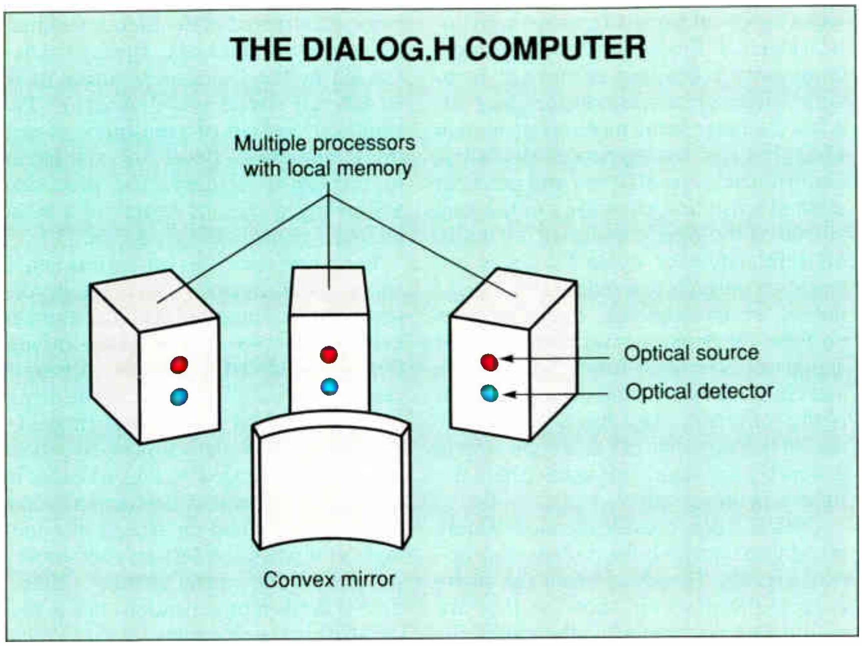

Figure 1: *The Dialog.H computer is one of the earliest examples of using photonic interconnections within a computer. It consists of a multitude of electronic processors, each with its own local memory.*

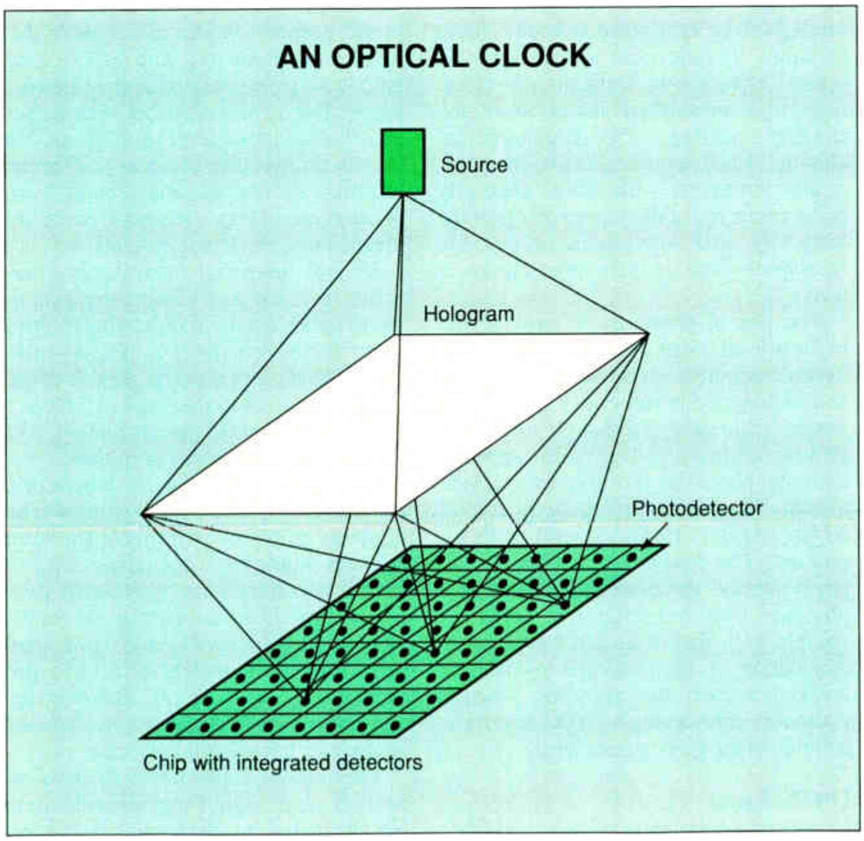

Figure 2: *Optical clock distribution to a chip via a holographic optical element. An off-chip semiconductor laser source generates an optical timing signal, which a holographic optical element then efficiently broadcasts to many photodetectors embedded in the chip.*

devices on the chip. The clock signal must be delivered to virtually all devices on the chip, and therefore suffers a high level of *fan-out*. That is, it is split many times so it can reach all the devices. Such splitting loads the clock lines so that it becomes hard to drive them with a high-speed electronic signal.

Stanford University has been working for several years on designing and fabricating chips that are clocked optically. As shown in figure 2, an off-chip semiconductor laser source generates an optical timing signal, which a holographic optical element then efficiently broadcasts to many photodetectors embedded in the chip. The optical signal is then converted to electronic form at many locations, and conventional chip wiring distributes each locally detected clock signal to nearby devices. Variations of this scheme incorporate many free-running clock oscillators on the chip, which an optical signal then synchronizes.

The Breaking Point

The use of photonics as an interconnect technology remains in its infancy. Electronic-systems designers have a natural tendency to select electronic (rather than photonic) solutions to problems simply because they are unfamiliar with the photonic approach.

However, in fairness, photonic devices need a great deal more development before they will be as reliable and flexible as electronic devices. Driven by the requirements of long-distance fiber-optic communications, this development will surely occur. When it does, photonics will gradually be incorporated into lower and lower levels of the interconnect hierarchy, especially in applications where the highest possible speed is essential.

The implication is that optics will probably provide viable interconnect solutions for the higher levels of the interconnect hierarchy but will eventually fall behind in competition with electronics on the lower levels. Where the breaking point will actually occur is at present the subject of considerable research. It appears highly likely that the typical computer of the future will depend on photonics, certainly for external interconnections, and probably for at least some of its internal interconnections.

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continued

Joining Forces

Optics and electronics each have their shortcomings, but together they combine the best of both worlds

Donald J. Channin

As clock speeds push toward 100 MHz and beyond, and as word lengths increase beyond 32 bits, conventional electronic means of interconnection will be severely tested. Without an alternative, copper, not silicon, will limit the performance and cost of future advanced workstations and processors.

The integration of optics with electronics offers an alternate interconnection technology called optoelectronic integrated circuit (OEIC) technology. Optoelectronic elements such as diode lasers and optical photodetectors are fabricated together on the same chips with electronic-circuit functions.

What can we expect from computers based on these chips?

- Faster, more economical machinery.
- Broadband interconnections for high-density graphics and ultimately real-time video, as part of the workstation environment.
- New architectures for computing, as optics liberate interconnections from the confines of computer and backplane wiring.
- Processors whose architectures can be custom-configured by electrically controlled beam interconnections.

Silicon-based logic and memory offer so much flexibility and potential for future development that optical systems will probably replace them only in specialized applications. The more general use of optics won't be to replace silicon but to support it. Ultimately, the OEIC technology could look like this:

- Chips in which optoelectronic devices replace the conventional I/O pads and associated line drivers for sending and receiving optical signals.
- Signal connections based on beams of light, fiber-optic lightguides, or planar optical waveguides embedded in printed wiring boards, or combinations of these elements.
- Economical packaging that supports the chips with their optical connections but doesn't need the hundreds of pins that now surround complex chips.

Why Go Optical?

The most obvious reason for these optical refinements is simply the number of pins on complex chips. Three hundred pins are common on processors today, and computer designers are anticipating packages with over a thousand pins in the early 1990s. This growth is a direct result of increasing complexity on the chip, which requires more I/O capability to support it.

Rent's Rule, an empirical rule for logic circuits, tells us that $N_c = K(N_g)^s$. N_c is the number of connections to a chip, and N_g is the number of gates the chip has. K and s are constants whose values are typically 2.5 and 0.6, respectively. If you put more logic on a chip, you must support it with more connections.

The use of optics won't be to replace silicon but to support it.

Packages with many pins devote most of their real estate to fan-out from the chip itself to the pins. Reliability drops and costs rise rapidly with increasing numbers of mechanical elements. By going to optics, single optical links can replace multiple pin connections.

Present printed wiring boards can handle current clock frequencies of about 30 MHz with little difficulty. But when clock speeds reach 100 MHz and beyond, as they undoubtedly will, the electrical characteristics of the board traces will degrade and ultimately limit system performance.

Low-speed systems use unmatched electrical impedances and expend power-charging line capacitance. This power grows with frequency. To avoid committing excessive chip power to driving these capacitances, you must shift to matched impedances for transmission lines and terminations. This step turns system design into an exercise in radio-frequency (RF) engineering. Electromagnetic interference and compatibility become major design issues.

All these problems spell increasing cost and lower system reliability. Optical links, however, offer the multi-gigahertz bandwidths and noise immunity that have given them a commanding position in fiber-optic telecommunications.

Geometry, Plain and Simple

While the very architectures of present computers are based on the geometries of multilayer boards and backplanes, light is not limited to these geometries. Beams of light can pass through each other and don't need a controlling medium. Such a beam can use the shortest path between two points in a system as a signal path. Changing the direction of such beams can amount to rewiring the machine.

Guided propagation of light in fibers or films is not as flexible, but it can still support layouts and system geometries impossible with conventional interconnections. New computing methods, such as massively parallel and pipelined processing, appear well suited for implementation on machines with the architectural freedom optics can offer.

To make these optically connected computers possible, you will need a CMOS processor, DRAM, or other typical computer chip. However, one or more optical-interconnect subchips would replace the hundreds of bonding pads that normally surround such chips. These subchips act as transmitters and receivers for optical data that otherwise would pass to and from the circuit through electrical connections.

Figure 1 shows the detail of the optical subchip. It is fabricated on GaAs, a semiconductor with properties different from those of silicon but capable of being grown directly on the silicon chip.

Data is sent in parallel to the subchip, converted to serial form by the signal processor, and used to drive a laser transmitter. Laser light modulated by the data is sent to another chip as an unguided beam or through an optical fiber. The receiver element accepts optical signals from other chips and converts them to electrical signals. Then the received signals are converted to parallel form and sent to the silicon master chip.

Signal Processing

Optoelectronic technology is based on using semiconductor devices for generating light signals from electrical inputs, transmitting them, receiving them, and converting them back into electrical form. Certain semiconductors, such as aluminum gallium arsenide (AlGaAs) for wavelengths of 0.8 to 0.9 micrometers (μm) and indium gallium arsenide (InGaAs) for wavelengths of 1.1 to 1.6 μm, generate these light signals by applying forward bias (i.e., low electrical resistance) to specially fabricated junctions.

Electrons and holes injected into the junction recombine there to create photons of light. These photons may be emitted directly to form incoherent light. Such a device (e.g., an LED) is easy to make but is slow and inefficient.

Laser diodes are made by incorporating the semiconductor junction into an optical cavity produced in the same material, so that optical feedback stimulates lasing action. Laser diodes can be efficient (more than 60 percent) and fast (more than 10-GHz bandwidth over which light intensity follows current modulation), and they use little current and power (less than 10 milliamps and less than 20 milliwatts). You can couple light from laser diodes into optical fibers for transmission or direct them into beams traveling in free space.

On the receiver side, photodiodes based on reverse-biased (i.e., with high electrical resistance) semiconductor junctions detect the light signals. Photons absorbed within the depleted regions of these junctions create electron-hole pairs that are swept out to create a small current that varies with the intensity of the light.

Simply switching the laser on and off with the drive current imposes information on the light beam. The photodetector current tracks this signal and can drive subsequent electronic stages.

A complete transmitter or receiver combines the lasers and photodetectors with electronic circuits that control their operation and provide an interface between them and the digital circuitry. You can also add digital circuitry to convert the parallel data into a single serial data stream to be transmitted over the optical link, and to reconvert the data to parallel form at the receiver. These multiplexing and demultiplexing (MUX/DEMUX) operations let you trade off the high-speed capabilities of optoelectronic devices against the greater chip area and power consumption of parallel optical-signal paths.

Assembling the Pieces

OEIC technology puts all these functions on a single semiconductor chip. Figure 2 shows an example of the type of chip now being developed (see reference 1). Conceptually, it makes sense to extend the functions on the chip to include logic, memory, and other signal-processing functions that the application needs. Three main issues are involved:

• Different device functions require different semiconductor materials.

Diode lasers can't be made in silicon, nor can photodetectors for the long wavelength optical bands (1.3 to 1.6 μm).

GaAs is excellent for short-wavelength (0.8 μm) lasers and detectors, and supports a growing field in high-speed logic. Unfortunately, it's not competitive with silicon for large-scale memory or logic.

InGaAs supports long-wavelength lasers and detectors. It also has a potential for even greater electronic speeds than GaAs, but it is still a relatively immature technology.

• Different devices require different and sometimes incompatible processing techniques.

Most laser structures are built up of semiconductor *heterojunctions*, which are crystalline layers of different compositions that are grown on top of each other with demanding requirements on the interface properties of the materials (see reference 2).

Electronic devices, by contrast, are usually made of single-composition materials with electrical properties modified by doping. Not only does fabricating a chip with both types of devices involve different processing for different system elements, but you must do it on a surface that has different elevations for different devices.

• Interfacing optical-transmission media (i.e., fiber optics) limits chip geometry and requires precise mechanical alignment in packaging.

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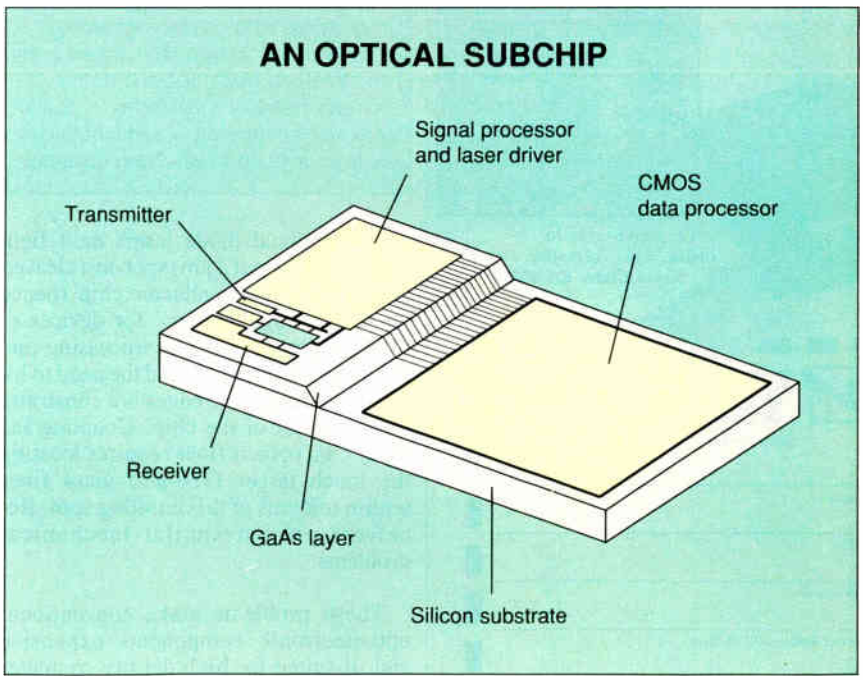

Figure 1: *An optical interconnect subchip. Note that it is fabricated on GaAs, a substance with properties different from those of the silicon substrate but capable of being grown directly on it. The OEIC computer chip itself is fabricated of silicon.*

Search and Research

The most focused research work has been in the field of monolithic integration of electronic and optoelectronic devices. The first milestone was achieved in 1978 when Caltech reported a basic transceiver chip containing a laser, amplifier, and photodetector on a gallium arsenide (GaAs) substrate.

Progress to more complex chips required planar surfaces for photolithography. To achieve that, Honeywell and other companies developed techniques to grow the laser heteroepitaxial layers in a well that is etched into the GaAs substrate.

Since then, fast (1 gigabit per second) and complex (more than 500 gates) transceiver chips have been developed. Receivers using planar photodiode devices have grown in complexity to more than 2000 devices per chip and in speed to over 5 gigahertz. Extensive work has been done in Japan, culminating with the first commercial part (a receiver) offered in 1988 by Matsushita.

This impressive progress was made despite the lack of a compatible processing technique for all the devices on the chips. Without a compatible process, low-cost products are unlikely to appear. This need has been recognized: Examples of compatible optoelectronic integrations have recently appeared.

Fujitsu has shown an approach in which lasers, detectors, and transistors are processed by implanting a planar material containing a semiconductor multiple quantum well. Such quantum-well structures are examples of how new semiconductor growth technologies can perform "atomic engineering" on materials. These technologies tailor the fundamental energy bands to the needs of the devices, rather than limiting device performance to the capabilities of bulk materials. With these techniques, development paths to economical fabrication of complete and complex optoelectronic IC parts are now open.

Another accomplishment in materials engineering addresses a problem involving computer chips and OEIC functions requiring different semiconductor materials. Now you can grow GaAs layers of device quality directly onto a silicon wafer. Originally, the objective was to provide a better substrate for GaAs electronic devices. But the same technology can allow islands of GaAs grown onto a silicon chip to add optoelectronic functions to conventional logic and memory.

The major technical issue is the crystalline quality of the GaAs as it grows on the different crystalline structure of silicon. Defects in the crystalline structure of the grown layers affect the performance and reliability of the devices fabricated on them. Although the quality of the GaAs must improve before reliable lasers can be manufactured, the goal of complete monolithic integration of optoelectronics to support the interconnection of electronic computing functions is now in sight.

Conventional diode lasers emit light from a tiny (about 2 μm) spot on a cleaved edge of the semiconductor chip (hence the term "edge emitter" for devices of this geometry). Special processing and handling are required, and the need to locate the lasers at the edges is a constraint on the layout of the chip. Coupling the light to an optical fiber requires locating the much larger (120-μm) glass fiber within microns of this emitting spot. Receivers present similar mechanical problems.

These problems make conventional optoelectronic components expensive and ill-suited for high-density computer hardware. However, a group of enabling technologies has emerged that makes OEIC development for computer applications feasible and timely. These technologies have come out of separate research efforts with very different objectives, but together they offer a realistic framework for OEIC design and fabrication (see the text box "Search and Research" above).

In the near term, the concept of multichip packaging now entering systems applications could allow GaAs and silicon chips to share the same package even before the technology for growing GaAs on silicon is perfected. Internal connections between the chips would still require electrical traces, but optics would carry signals outside the packages.

Interfacing OEIC chips for optical transmission has been made much easier with the recent development of surface-emitting diode lasers. Unlike the conventional edge-emitting lasers, these new devices have optical emission perpendicular to the chip surface. No longer must

OEIC layouts be constrained so the laser output comes from the cleaved and processed edge of the chip.

An example of such a device is the grating-surface-emitting (GSE) laser announced by the David Sarnoff Research Center (see figure 3 and reference 3). This device uses a diffraction grating processed into the laser to deflect light from the plane of the chip into a narrow beam. This beam can then go directly into a receiver on another OEIC chip, be redirected with lenses or other optics, or be coupled efficiently into fiber optics. Other approaches to surface-emitting lasers use micromirrors etched into the chip to deflect light, or invert the laser itself so that it is oriented perpendicular to the chip surface.

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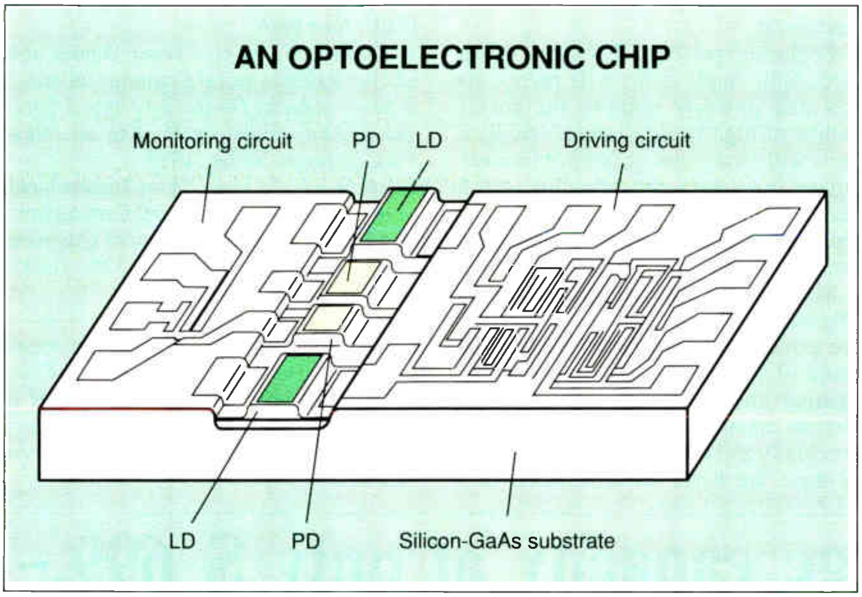

Figure 2: *An example of the type of optoelectronic chip now being developed. It shows a typical OEIC structure containing laser diodes (LDs), photodetectors (PDs), and driving and monitoring circuits.*

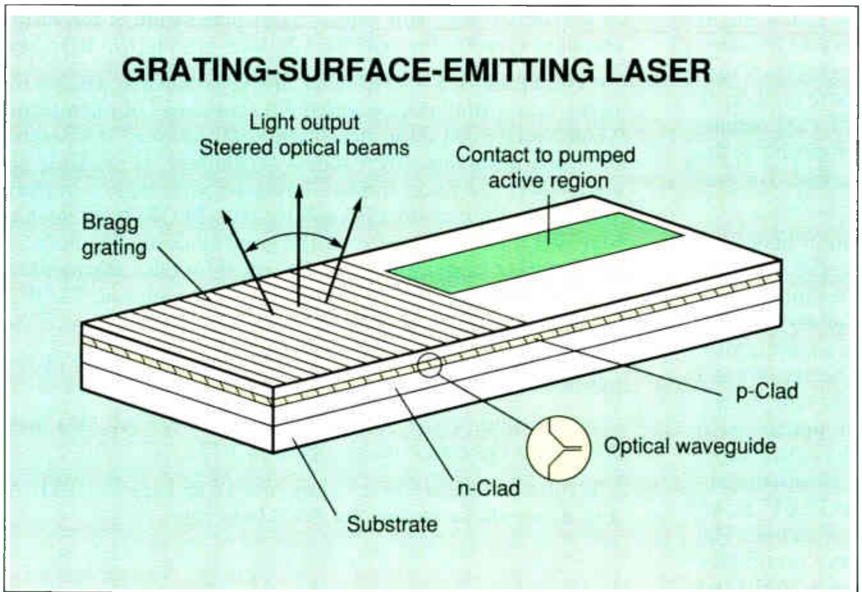

Figure 3: *Grating-surface-emitting (GSE) laser structure. Light output is in the form of steered, focused, narrow optical beams from the surface of the diffraction grating. Current from the contact to pumped active region stimulates optical emission in the optical waveguide.*

A special feature of the GSE laser approach is that the light beam can be electronically steered. Two optical processes combine to achieve this effect. First, the deflection angle of light from the grating changes with the light wavelength. Second, the electronic drive to the laser controls the light wavelength. Combining these two effects will make it possible to electronically change where the output beam points.

The Age of Optics?

What could we do with a steerable optical interconnection? To start with, we could eliminate a major bottleneck in processor performance by replacing current data bus architectures with direct connections between processors and memory. Such direct connections make sense only if you can switch them in real time, as you can with electronically steerable optics.

Going further, you could base architectures for parallel-processing machines on direct, equal access among all processing elements, rather than on the restricted access that electronic connections offer. Ultimately, we may have workstations in which the processing system alters itself according to the application it is running or even the specific task it is carrying out.

Will we see such machines soon? Both technology and market issues will set the pace for the development of the OEIC chips around which they must be designed. The first users of OEIC devices will probably be not computer manufacturers but makers of telecommunications equipment.

Replacing present fiber-optic equipment with single chips will reduce the cost and probably improve the performance of high-speed systems. Applications will first come as fiber-optic interconnections between computer-room equipment and high-speed networks to replace the bulky electrical cables now used. Cost reduction is the driving force.

Meanwhile, organizations such as the Microelectronics Computer Consortium are exploring the architectural implications of optical interconnections for existing and new types of computers. Various companies are also working, individually and within industry groups, to advance the basic semiconductor technologies and prepare for production. With this activity, the 1990s should be the decade for introducing optics into computers. ■

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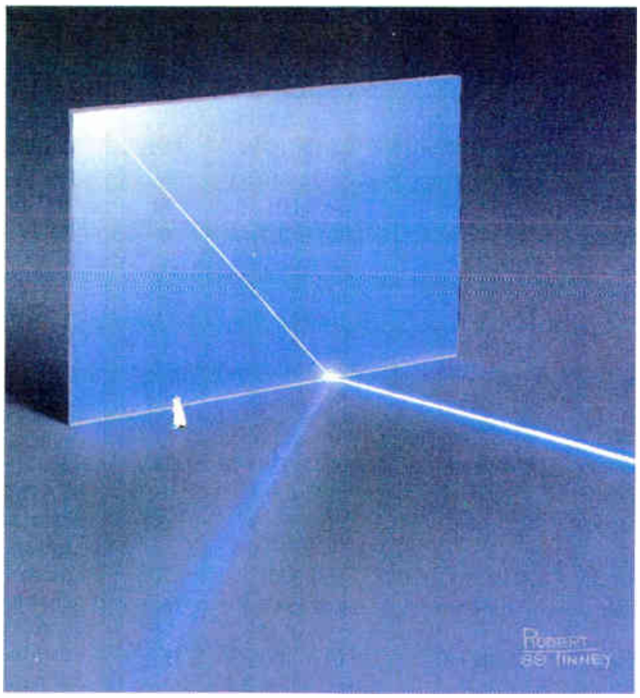
Reflected Light

Lasers are the way to go for brightness and sharpness in a world dominated by speed and resolution

Gary T. Forrest

A spot of light can never be too small or too bright. This emphasizes the two fundamental user advantages of *lasers* (light amplification by stimulated emission of radiation): sharpness and brightness.

Sharpness refers to a laser beam's ability to be focused to a *diffraction limited spot*—that is, a spot limited in size only by the wavelength of the light. *Brightness* refers to the amount of light delivered to a target area. It depends on the spot size and the amount of energy in that spot. With a 100-watt light bulb, you can read a book; with a 100-W laser, you can burn a hole in the book. Lasers come in many forms, including gas, solid-state, and semiconductor designs. Each form has its own range of output wavelengths and power (see figure 1 and the text box "Laser Power" on page 250).



Approaching its thirtieth birthday, laser technology has finally begun to have a major impact on our lives. Lasers are now in many of our homes inside compact disk players (with CD video coming soon). Laser bar code scanners tabulate prices and update inventories in our stores. Laser printers are used for high-quality hard-copy output. And earlier this year, erasable optical data storage received a major boost when NeXT introduced a workstation with the Canon erasable optical disk drive. But these developments are just the beginning.

Resolution vs. Speed

The two fundamental properties, brightness and sharpness, determine the density and speed that a specific application is able to achieve. Take, for example, a laser printer that uses a semiconductor laser, like the one in figure 2. A shorter-wavelength laser diode (say, of 680 nanometers versus the 780 nm presently used) will print a smaller spot size on the paper, thereby increasing the resolution.

But the power delivered to the paper—the brightness—will determine the printing speed. Currently, 680-nm laser diodes are available commercially with up to 5 milliwatts of power; on the other hand, 780-nm laser diodes (a more mature technology), are available with powers of up to 100 mW. So 780-nm diodes currently dominate laser-printer and data-storage applications.

In the past, the available types of lasers often dictated the results of the resolution-versus-speed trade-offs. For example, you can find visible-output gas lasers using krypton gas with powers of several watts that have wavelengths shorter than 780 nm (see figure 1 and table A), so why not use them in laser printers? Gas lasers have been used in printers, but they range in size from a

continued

Laser Power

Lasers are generally characterized by their output wavelength, measured in nanometers, microns, or angstroms. For a given type of laser, the output wavelength can often be changed by altering the laser medium.

For example, an excimer laser can operate on mixtures of argon fluoride, krypton fluoride, xenon chloride, and xenon fluoride, with corresponding output wavelengths of 193, 248, 308, and 351 nm, respectively.

In other cases, such as argon-ion lasers, there are several possible lasing transitions, which (depending on the reflectivity of the optics coatings) can allow operation at 488 nm, 514.5 nm, and various other ultraviolet and blue/green wavelengths.

In the case of semiconductor lasers, the output wavelength is determined in part by the composition of the active region. The most common laser diodes are those used in compact disk players (780 nm) and for telecommunications (1300 to 1550 nm). Although a wide variety of laser-diode wavelengths is possible, economic considerations often limit those available commercially to relatively few.

Although the most commonly used solid-state lasers are neodymium-doped yttrium aluminum garnet (YAG), you can use other lasing hosts (including glasses and crystals) and dopants. Other hosts are actually preferable when you need specific wavelengths. In addition, you can convert the output of a laser to a different wavelength using various dyes and nonlinear materials.

Among the most popular of these conversions in recent years has been converting the infrared output of solid-state lasers at 1064 nm to 532 nm (in the visible-spectrum region). Another example is generating ultraviolet output starting with frequency-doubled solid-state lasers (converting 532 nm to 266 nm) or argon-ion lasers (converting 488 nm to 244 nm).

In considering a laser for a particular application, the most important criteria are those in table A. (The lasers listed are only a fraction of the nearly 200 models and types of lasers listed in the *1989 Laser Focus World Buyer's Guide* [Tulsa, OK: PennWell Books].) Lasers often require significant adjustments to achieve various output wavelengths.

Similarly, the power available may depend on the specific wavelength. For example, dye lasers (not discussed here) use a liquid lasing medium, pumped by either a laser or a flash lamp. You can operate these lasers in either a pulsed or continuous-wave (CW) fashion with foot long to several yards long, and they require air cooling and often water cooling.

Laser diodes have solved this problem. Laser diodes the size of a grain of sand are now packaged in small, hermetically sealed cans less than a centimeter in size. Building on the explosive success of CD players (going from a few hundred units per year to millions in just a few years, and driving the laser-diode price from hundreds of dollars down to single-digit prices), Canon was able to marry small, inexpensive laser diodes with low-cost personal copier designs. The result was the personal computer laser printer.

Table A: *The lasers are listed in order of their low-end wavelength (see figure 1 for a graphical description). Power measurements are given in watts (W) and joules (J), and size is given as small (S), medium (M), and large (L).*

COMPARATIVE PROPERTIES OF COMMON LASERS

Laser	Type	Wavelength	Power	Size
Excimer	Gas	193 to 351 nm	0.01 to 1 J	L
Argon ion	Gas	257 to 514 nm	0.01 to 20 W	M, L
Helium cadmium	Gas	325 to 442 nm	0.001 to 0.075 W	M
Nitrogen	Gas	337 nm	< 0.001 J	M
Doubled diode	Semiconductor	432 nm	0.001 to 0.01 W	M
Copper vapor	Gas	510 to 578 nm	< 0.005 J	L
Doubled YAG[1]	Solid state	532 nm	0.001 to 2 W < 0.001 to 0.5 J	M, L
Gold vapor	Gas	628 nm	< 0.002 J	L
Helium neon	Gas	632 nm	0.001 to 0.1 W	M, L
Krypton ion	Gas	647 to 676 nm	0.1 to 5 W	M, L
Titanium sapphire	Solid state	670 to 1040 nm	0.1 to 3 W	L
InGaAlP[2]	Semiconductor	680 nm	0.001 to 0.01 W	S
Ruby	Solid state	694 nm	1 to 100 J	M, L
GaAlAs[3] diodes	Semiconductor	780 to 880 nm	0.001 to 1 W < 0.001 J	S
GaAs[4] diodes	Semiconductor	890 to 1060 nm	< 0.0001 J	S
Neodymium YLF[5]	Solid state	1047 nm	0.02 to 17 W < 0.001 to 2 J	M, L
Neodymium YAG	Solid state	1064 nm	0.01 to 1000 W < 0.001 to 2 J	M, L
InGaAsP[6] diodes	Semiconductor	1300 to 1550 nm	0.001 to 0.1 W < 0.000001 J	S
Carbon monoxide	Gas	5000 to 7000 nm	3 to 20 W < 0.01 J	M, L
Carbon dioxide	Gas	9000 to 11000 nm	1 to 5000 W 0.1 to 500 J	M, L

[1]Yttrium aluminum garnet
[2]Indium gallium aluminum phosphide
[3]Gallium aluminum arsenide
[4]Gallium arsenide
[5]Yttrium lithium fluoride
[6]Indium gallium arsenide phosphide

Designed by Computer

Lasers and computers have entered into a synergistic phase. At the simple mechanical-design level, the laser industry uses CAD/CAM systems to design and fabricate high-tolerance mechanical parts. Lasers require alignment tolerances of mere fractions of a wavelength, so mechanical precision is essential in their construction. For a typical visible laser, this means tolerance on the order of tens of nanometers.

Looking a little deeper, computers are used to optimize laser-cavity designs. This is accomplished by what-if iterative *ray tracing*, following the optical path of the light in the laser cavity as various design parameters change (see figure 3).

For example, one of the main factors contributing to the operating efficiency of a laser is matching the *pump-mode volume* (the area that the pump light illuminates) to the *lasing-mode volume* (the powers up to 1.5 watts and energies up to 3.5 joules. By changing the lasing dye, you can adjust the output wavelength from 205 nm to 1000 nm, depending on the design of the laser and the pump or lamp used.

To accomplish a specific task, such as welding or writing to an optical disk, the power or energy of the laser is an important characteristic. CW lasers put out a constant power, usually indicated in watts, milliwatts, or microwatts. Pulsed lasers are rated in joules, millijoules, or microjoules.

You can pulse a laser with several different techniques, depending on its design. For example, you can pulse the flashlamp used to pump the laser, resulting in a pulsed laser output. You can also place a high-speed (i.e., where the speed is measured in nanoseconds) shutter inside the laser cavity and use it to periodically interrupt the laser beam. This results in a pulsed output with a duration of a few tens of nanoseconds. For semiconductor laser types, you can pulse the input current with a TTL-type signal or very short picosecond pulses, again resulting in pulsed output.

The primary purpose of pulsing a laser is to achieve higher *peak powers*—that is, greater energy per unit time. Using these techniques, you can achieve gigawatts of peak power; in some specialized lasers (like those used for laser fusion), you can even achieve terawatts of output power. It is common for the same lasing material to come in either a CW or pulsed design. A few of the more common ones that come in both are neodymium YAG, carbon dioxide, and the semiconductor laser diodes.

Finally, the overall size of the laser can be important, as lasers are often built into other equipment. For example, a laser-based air-pollution monitoring system that has to be carried in a small airplane must be small enough to fit in the plane and must be compatible with the electrical and water-cooling utilities available.

In table A, the classification of size is L for large (more than 1 meter in length, usually requiring water cooling and 220- or 440-volt electrical power), M for medium (roughly the size of a shoe box, often 110-V powered and air-cooled), and S for small (typically requiring low voltages for operation and packaged in electronics-type housings with dimensions measured in centimeters or less). The size is often dependent on the output power of the laser, as higher-power lasers require more active lasing area and typically generate more waste heat that needs to be removed.

active region of the lasing material). Design iterations done on a CAD system allow you to optimize these two volumes for maximum overlap and efficiency.

With laser diodes and electro-optic devices, you can model the simultaneous interaction of electric and optical properties. For example, Spectra-Physics (Mountain View, CA) made extensive use of a microcomputer-based CAD system in designing its new titanium-doped sapphire laser.

For their basic operation, lasers require optical coatings that have unique reflective properties. Virtually all lasers have a highly reflective rear-mirror surface as well as a partially reflective front surface that emits part of the laser light (see figure 3). Some surfaces need to be antireflective and allow light to be coupled into the laser or a device efficiently.

If lasers came in only one type and one wavelength, then designing coatings to achieve these reflectivities would be a one-time problem. But the wide range of wavelengths available requires almost as wide a range of materials for both reflective surfaces and coatings. As a result, multiple layers of materials are used to coat optics forming *stacks*. The thickness of each layer is a fraction of the wavelength of the light being reflected.

Computers now let you determine the physical parameters you want and then use a computer model to calculate the required coating geometry. In addition to coatings, CAD-generated optics let you draw and fabricate (by diamond turning)

continued

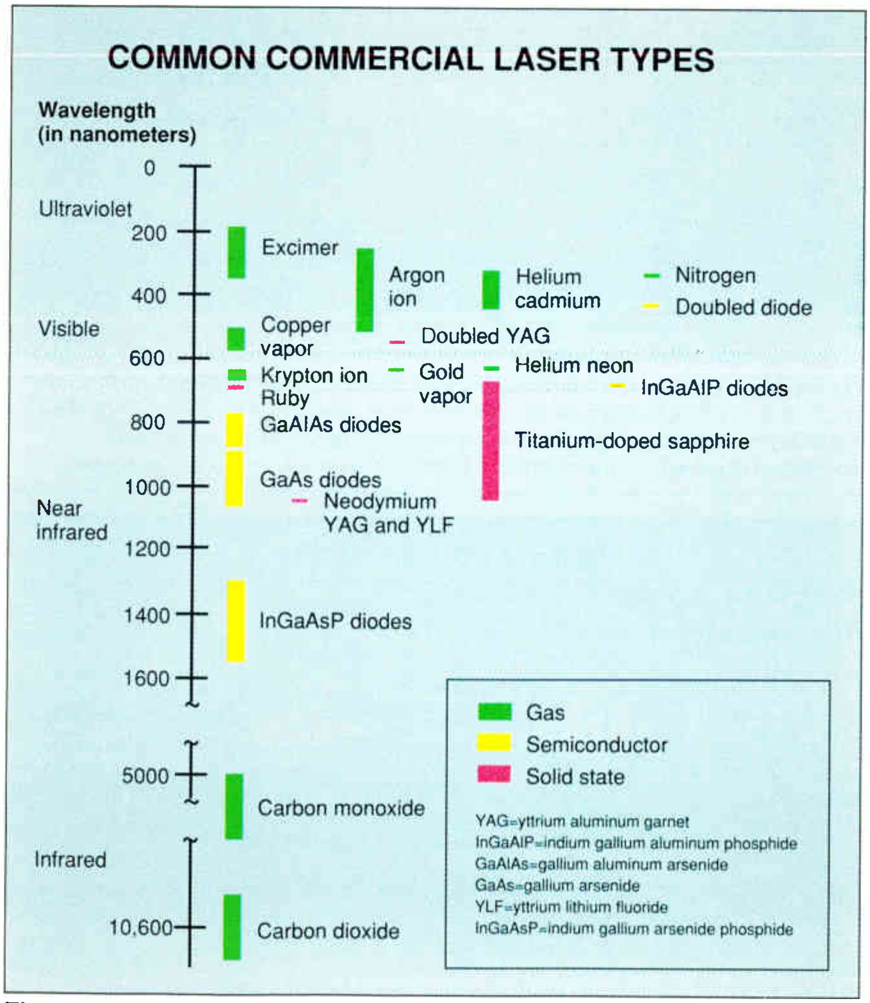


Figure 1: *The three types of lasers shown here—gas, solid-state, and semiconductor—are all capable of generating visible light. (See table A.)*

unique aspheric surfaces completely under computer control.

Controlled by Computer

For the laser's advantages of brightness and sharpness to be useful, you often need to manipulate the direction it points in. In addition to simple fixed and scanning mirrors, scanning galvanometers and electro-optic deflectors are the most common ways of moving laser beams around. Or, instead of moving the laser, you can move the work piece with a motor.

Such computer-controlled systems can be as simple as an AT&T PC 6300 driving a motorized microscope stage under control of CAD Design 3 (see photo 1) or Harvard Graphics for micromachining. Or they can be as sophisticated as using a Personal Iris system from Silicon Graphics (Mountain View, CA) as the CAD/CAM interface to the Stereolithography Apparatus from 3-D Systems (Valencia, CA), which moves an ultraviolet laser beam under computer control through a polymer matrix to fabricate prototype plastic parts. 3-D Systems also offers 80286/DOS- and 80386/Unix-controlled systems for which you provide your own CAD/CAM interface.

In the most general sense of automated control, you can control lasers over conventional RS-232C and general-purpose interface bus interfaces and coordinate their action with other test and fabrication devices. For example, Questek (Billerica, MA) used National Instruments' (NI) LabView software to control the micromachining functions of its excimer-laser system, which you can interface with VersaCAD (see photo 2).

In the laser-equipment field, last year the Newport Corp. (Fountain Valley, CA), the leading optical-equipment catalog-supply company, became the exclusive catalog distributor for LabView and LabWindows (NI's software for optics applications, for Macintosh and IBM PC-compatible computers, respectively). In the laser community, this is tantamount to a major endorsement of computer control and coordination of lasers and test instruments (see photo 3). As a result, laser companies have begun to offer hardware and even customized software interfaces for computer control of laser functions.

At a more subtle level, lasers have had a dramatic impact on workstation performance. In 1988, during the DRAM shortage, availability of 1-megabit DRAMs made the difference between having and not having high-performance workstations. The long-time leader in using lasers for memory repair, Electro-Scientific Industries (ESI) (Portland, OR), dramatically improved chip yields through a process of removing defective memory cells.

ESI uses a new all-solid-state laser technology: Q-switched, diode-pumped, solid-state lasers that operate under the control of proprietary software running on a Hewlett-Packard 9000 Series 300 computer. These lasers cut specific links on the IC with a short laser pulse only tens of nanoseconds long. They have an operating period without maintenance 10 times longer than that of similar flash-lamp-pumped lasers. Using this laser-

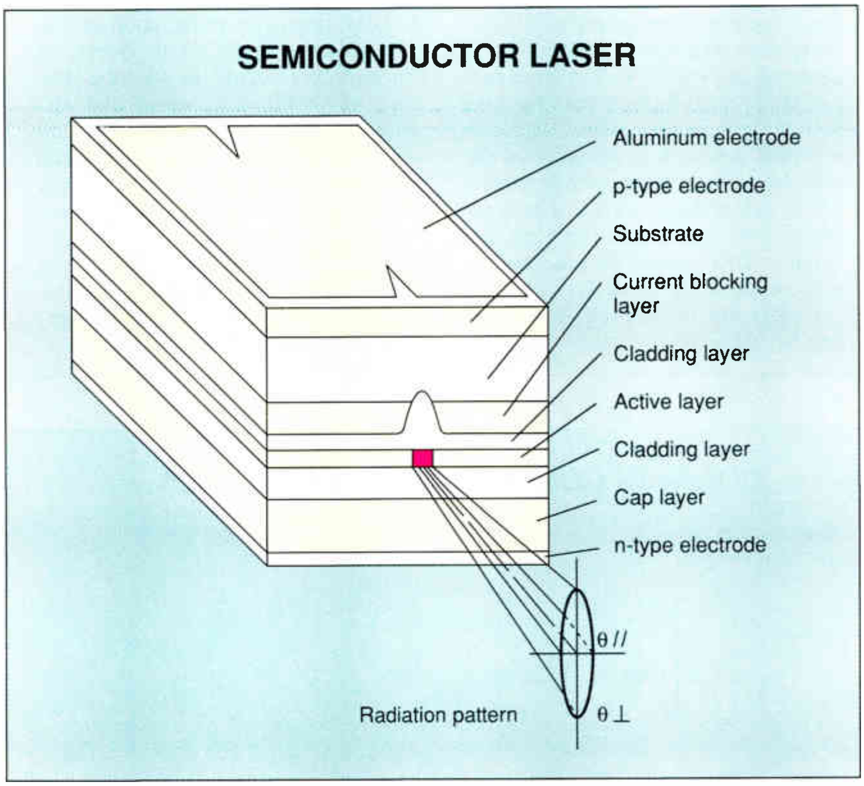


Figure 2: *Illustration of a typical laser-diode cavity design. Reflective surfaces on the front face (shown) and rear face (hidden from view) define a laser cavity. The active layer is composed of gallium aluminum arsenide, with the wavelength determined primarily by the relative amounts of Ga and Al in this active region.*

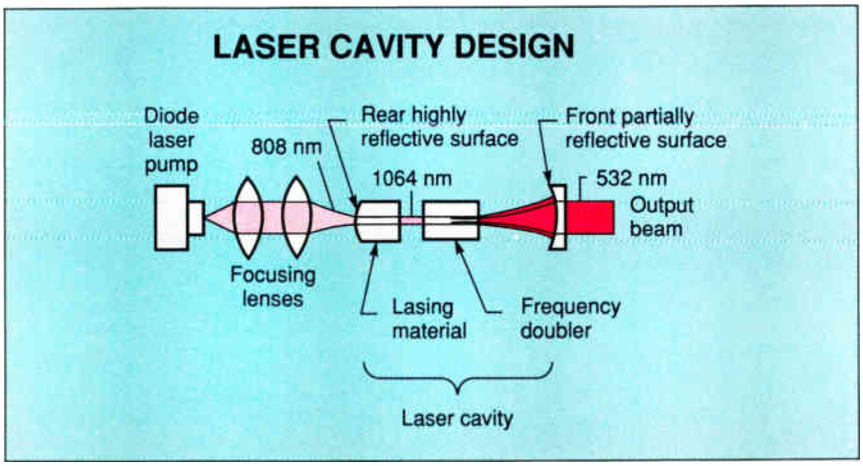


Figure 3: *A CAD-generated, diode-pumped, frequency-doubled laser cavity. It illustrates the conversion of low-quality infrared diode-laser-pump light to high-quality infrared (1064 nm) and visible (532 nm) light in an all-solid-state design.*

repair technology allowed the DRAM supply to catch up with demand.

Lasers have now become the de facto standard in testing IC devices as well; solid-state and xenon gas lasers operating in the infrared and green wavelength regions are preferred. At Semicon West in May in San Mateo, California, lasers appeared in all the failure-analysis stations displayed in the form of manual-probe stations. But powerful new automated computer verification and test software, such as Merlin's Workbench from Knights Technology (Cupertino, CA), allow the full integration of electrical testing and evaluation with laser processing—all operating under SunWindows.

As the electronics industry moves toward higher-resolution linear circuits and mixed analog and digital circuits, lasers are playing a critical role in fabricating thin-film resistors. High-precision resistor trimming allows higher-resolution D/A convertors to be made with greater linearity. The laser trims the device by cutting a continuous groove (thus changing the resistance) during device testing.

In addition to ESI, such thin-film hybrid resistor-trimming systems using long-lived, Q-switched, diode-pumped, solid-state lasers are now offered by Teradyne Laser Systems (Boston, MA) and XRL, Inc. (Norwell, MA). Both of these companies use Sun-3 workstations as the primary user interface. In a closely related application, Micrion Corp. (Peabody, MA) has developed a large-screen LCD thin-film resistor-repair system that uses the same type of all-solid-state infrared laser, but now frequency-doubled from 1064 nm to 532 nm for green-light output. This is accomplished by using a nonlinear frequency-doubling crystal, potassium-titanyl phosphate.

Together with CAD systems, lasers are a major facilitating factor in the evolution of machines that are designed and built by other machines. Other examples include using helium-neon (HeNe) lasers in interferometers for precise distance measurement and in pointers for alignment, excimer lasers for high-density deep-ultraviolet semiconductor lithography, ultrafine printed-circuit-board hole drilling, surface-mount printed-circuit-board component attachment by tape-automated bonding, and laser cutting and soldering. The common element in these areas is the use of computers to precisely position and control the laser beam, allowing the application to make maximum use of the brightness and sharpness of the laser beam.

continued

Photo 1: *A Q-switched, diode-pumped, neodymium yttrium-aluminum-garnet laser from Spectra-Physics, attached to a microscope. Under control of the AT&T PC 6300, a CAD Design 3 image is being scribed onto a coated plate. The two monitors show the CAD image (in color) and a section of the scribed image (in black and white). Nicknamed the "Laser Blade," this system is unique in that the diode laser-beam pump light is transported from a power-supply box to the neodymium YAG laser head via an optical fiber. This results in a very small, pencil-size laser head that you can attach directly to the microscope. (Photo courtesy of W. Scarvie, Spectra-Physics, Inc.)*

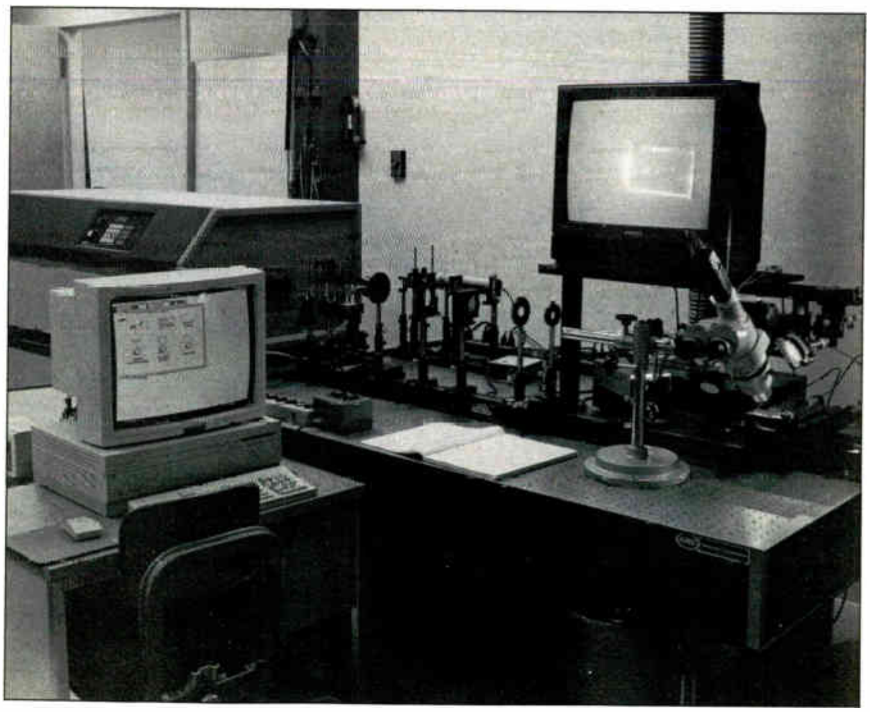


Photo 2: *An excimer laser interfaced with a CAD system, and the same laser controlled by a Mac II under LabView. (Photo courtesy of Questek, Inc.)*

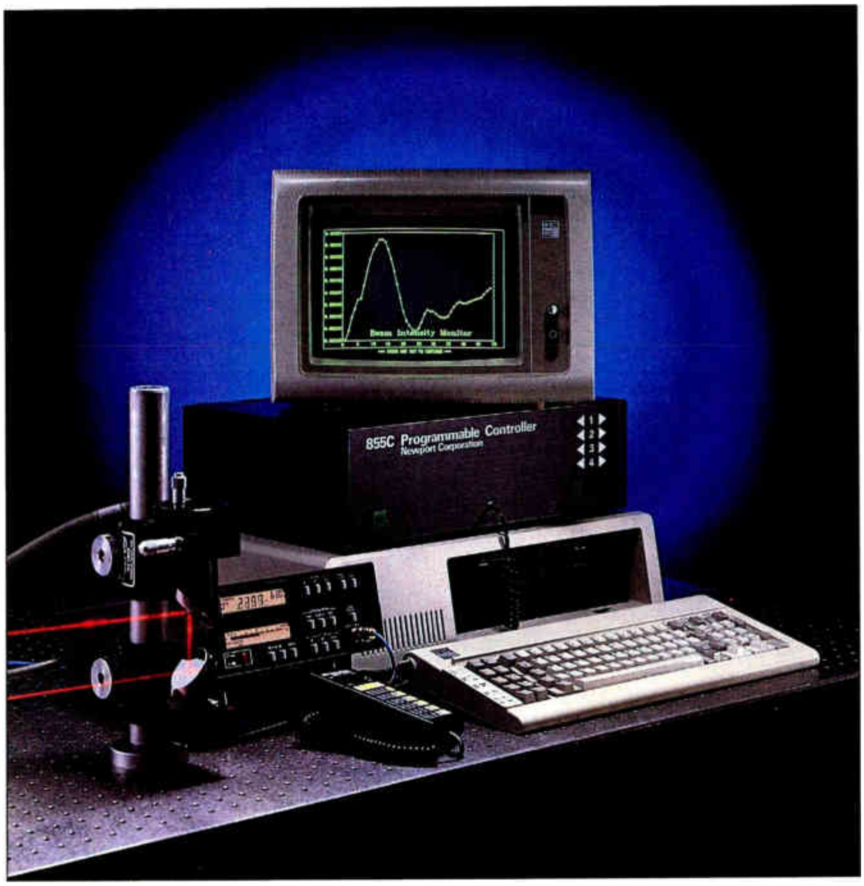


Photo 3: *National Instruments software, controlling instrumentation for testing lasers. Notice the power meter and stage-positioning system integrated with an IBM PC under the control of LabWindows. The CRT display shows the laser-beam intensity. (Photo courtesy of Newport Corp.)*

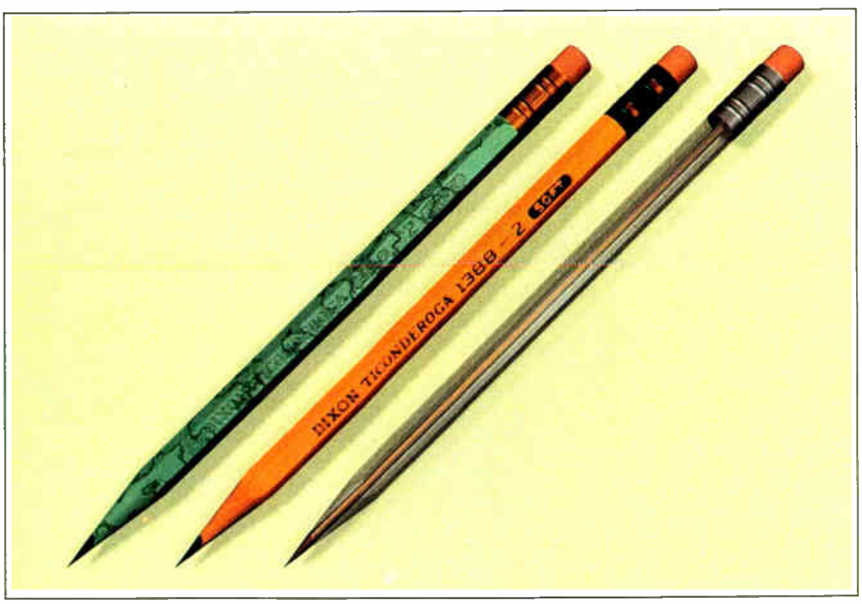


Photo 4: *This image was generated using Pixar's RenderMan software and printed directly on color film using three visible wavelength lasers. (Photo courtesy of Pixar, Inc.)*

Better Performance with Laser I/O

Laser technology has also had a major impact on computer input and output devices. High-resolution input scanners require the sharpness of lasers, and the *monochromaticity*, or single-color nature, of lasers has made them the standard for scanning documents for color separation and digitization. The most popular lasers for these applications have been red (632 nm) HeNe and blue/green (488 nm and 514.5 nm) argon-ion lasers. These lasers have beams that are visible to the human eye, so they are easy to align in scanning systems, and when focused to small spot sizes, printers and scanners can operate at high speeds.

Optical data storage in the form of CD-ROMs, WORMs, and now erasable optical data storage allow huge increases in storage capacity because of the small size of the laser beam spot. In the past, the lack of reliable high-power (more than 30 mW) laser diodes for the erasure cycle held back the development of erasable optical data storage. At lower powers, erasure was too slow for commercial acceptance. Now, high-power lasers (more than 50 mW) are available that can be focused to small spot sizes.

Much-higher-power lasers (over thousands of milliwatts continuously and tens of thousands of milliwatts when pulsed intermittently) are available from laser diodes, but the laser design results in much larger beam sizes, which negates a key reason for using the laser in the first place—a small spot size.

The next revolution in optical data storage is likely to occur quickly, with 680-nm laser diodes replacing 780-nm laser diodes to increase storage density. Although the shorter 680-nm wavelength can achieve a smaller spot, the output power of the 680-nm devices is currently limited to about 30 mW (and most suppliers will guarantee the lasers up to only about 5 mW).

One of the most easily recognized laser applications is bar code scanning: both the slot scanners used in stores and the hand-held scanners used for inventory control. Historically, these scanners, which measure the light reflected from the patterns of bars, have used HeNe gas lasers emitting at 632 nm.

The bars encode price and other information tied into an inventory-control system. Virtually all products sold to the U.S. government must have bar code identification labels. Manufacturers are upgrading production lines to track parts by bar codes and to automate warehouse storage of assembled products.

continued

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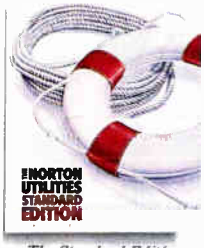

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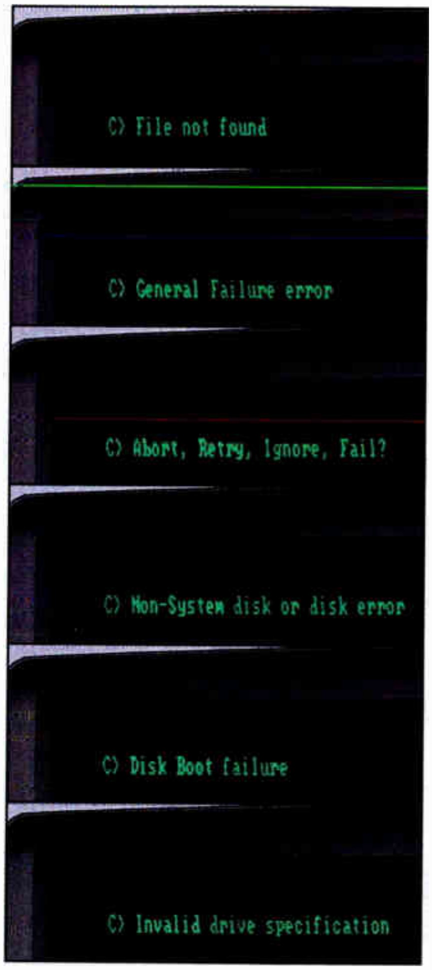

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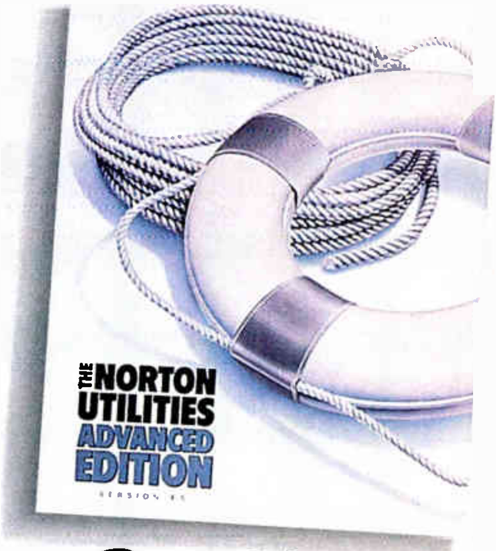

Peter Norton
COMPUTING

Circle 319 on Reader Service Card

New red (680-nm) laser diodes are having a profound impact on hand-held bar code scanners. Laser diodes operate at much lower currents than HeNe lasers, making hand-held bar code readers possible. (780-nm laser diodes can read the bar codes, but some colors show poor contrast at this longer wavelength.) This change in technology will probably lead to using bar codes on even more products as bar code scanners become smaller and less expensive.

Color Is Coming

Perhaps the biggest change of all is yet to come: full-color laser-printed images. Pixar (San Rafael, CA) and Kodak (Rochester, NY) have invested in several levels of laser technology to demonstrate that three primary-color lasers can generate high-resolution color output.

Several years ago, the only lasers available were large, often water-cooled, gas lasers. Now, laser diodes have generated three new classes of laser devices: red (680 nm) laser diodes, frequency-doubled green (532 nm) diode-pumped solid-state lasers, and directly doubled blue-output (432 nm) laser diodes.

More recently, Kodak has pursued a pure infrared laser diode design, in which each laser diode represents the intensity information for one of the three primary colors. But the need for three closely spaced wavelengths in the 780-nm to 880-nm range severely limits this approach.

Pixar has used a more conventional concept based on three visible lasers, with a 532-nm frequency-doubled solid-state laser replacing the previous 528-nm argon-ion gas laser. The new solid-state laser occupies about one-tenth the space. More important, it has an output wavelength with less *spectral overlap* with the red light response of typical photographic film and papers. This means that the green exposure has less effect on the red emulsion layer, and the final result is a purer red color tone in the photograph (see photo 4).

The remaining missing link is a blue solid-state laser, but IBM, Amoco Laser (Naperville, IL), and Spectra-Physics have shown in the past year that such lasers can be made with powers of several milliwatts—and potentially much higher power.

Originally developed in the Industrial Light and Magic group at LucasFilm, the laser scanner (which can be used as both an input scanner and an output printer) is now part of the Pixar electronic-darkroom project. The system operates by simultaneously scanning three laser beams across the film to write (or read) information about the color tone and intensity at each pixel.

The premise is very simple: Whether the image is completely computer-generated (in the case of the Pixar RenderMan software) or originates from an electronic camera, at some point you'll want to show the results to someone else. The solution is hard-copy output that retains the color fidelity and sharpness of the original image. Of course, if you didn't like the original image, changes are only a few keystrokes away. ■

Gary T. Forrest is president of FYI Reports and provides writing and consulting services to companies in the laser and optoelectronics fields. He has a Ph.D. in chemistry from MIT, where he used lasers for biomolecular research. He can be reached on BIX c/o "editors."

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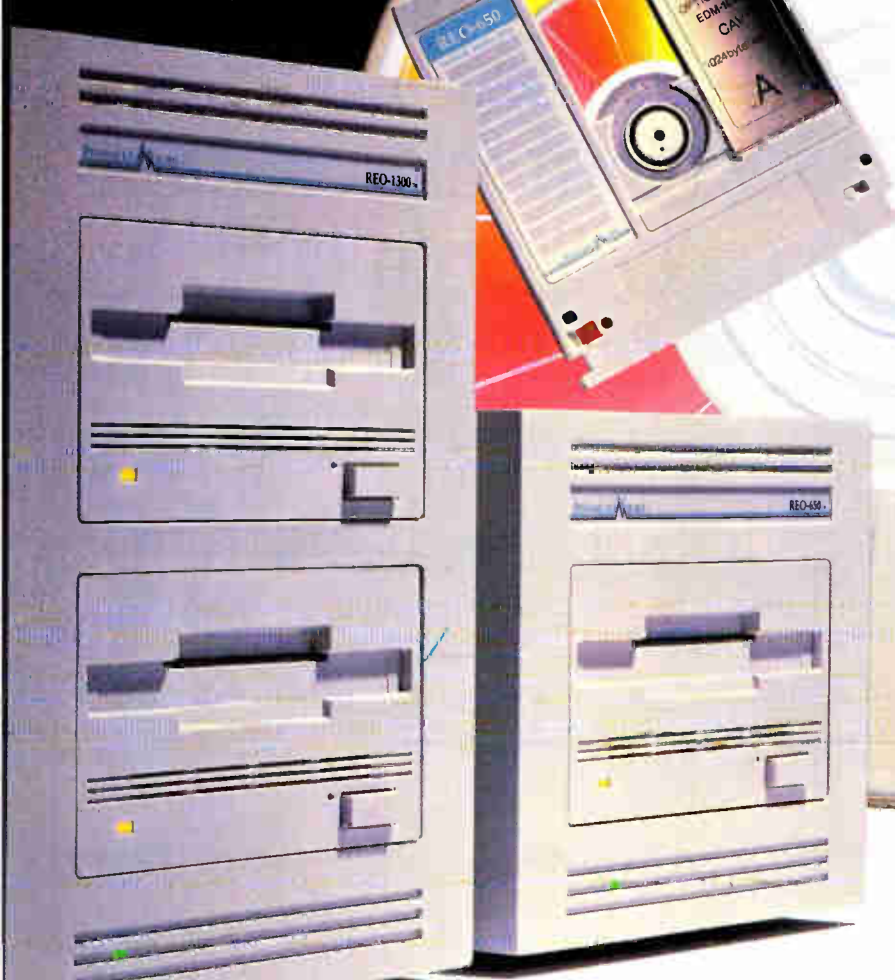

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Erasable optical storage brings mass storage to the masses

James J. Burke and Bob Ryan

Although backed by the likes of Sony, Philips, and Microsoft, optical storage has yet to catch on with most personal computer users, mainly due to the lack of a read/write capability. Now, with the introduction of rewritable optical disks, optical storage has become a potent rival to magnetic storage.

Rewritable optical technology is the most recent addition to the line of optical-storage products. CD-ROM—the original read-only optical-storage technology—has been available since the mid-1980s. And more recently, WORM (write once, read many times) technology has made an impact in areas requiring the random-access retrieval of permanent, nonerasable data and images. WORM "jukeboxes" with more than 1 terabyte (1 million megabytes) of storage have found their way into large government and business operations. With such a device, you can access any business document or engineering drawing in 10 seconds or less.

The Optical Advantage

All types of optical storage have certain advantages over magnetic storage. The primary advantage is storage density: You can get a lot more information on an optical disk than on a comparably sized magnetic disk. Due to the precision with which a laser can be focused, recording tracks on an optical disk are much closer together than tracks on a magnetic disk. Also, the amount of space needed to record an optical bit is much smaller than that used by magnetic media.

Another advantage of optical recording is that it is a great deal less sensitive to deterioration or contamination than magnetic recording media. This is because nothing touches the active recording layer except for the beam of light. The transparent substrate keeps dust and dirt from the focal spot so they cannot change the reflected signal substantially.

Optical disks are also far less susceptible to head crashes than are magnetic disks. Typically, an optical disk head comes no closer than 1 millimeter from the disk substrate. In contrast, the high-performance head of the IBM 3380 magnetic drive flies just 0.25 micrometer (μm) from the surface of the disk.

It has taken 30 years of research and development to learn how to produce reliable devices with such flying heights. Even at that, head crashes still occur. For obvious reasons, any attempt to remove a high-performance hard disk from its drive would be the end of the useful life of both. Optical disks, on the other hand, are easily loaded and removed, thus enabling the massive storage capacity of jukeboxes.

continued

ILLUSTRATION: ROBERT TINNEY © 1989

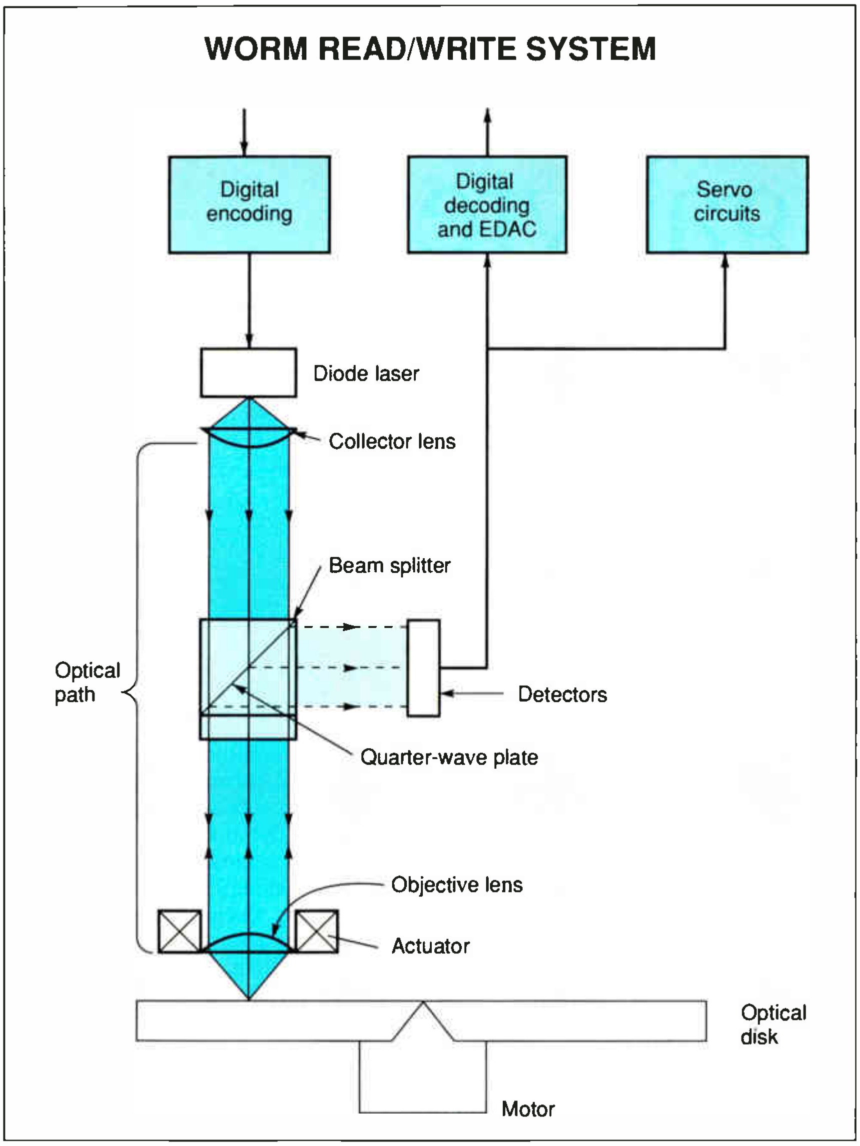

Figure 1: *A strong laser pulse writes by creating a pit (or a bubble) at the recording layer. The reflectivity of the weaker read beam is analyzed to detect the presence or absence of pits. Compact-disk systems are very similar, except, of course, that they are read-only. (Figure courtesy of Paul Y. Hu)*

Standards

Optical disks come in a variety of sizes and constitutions. You can buy 5¼-, 8-, 12-, and 14-inch WORM drives. Compact-disk media, whether carrying digitized audio, computer data, or both, are standardized to 120 mm (4.724 inches). Thanks to standards defined by Philips and Sony, CD-ROM disks from all suppliers use the same protocols and are thus readable in all players. They are becoming the medium of choice for publishing extensive documentation. The opposite is true with WORM drives: Data written on one vendor's WORM drive usually cannot be read by another's.

Most of the rewritable optical products announced thus far use 5¼-inch disks and promise to be interchangeable. It's too early to judge whether experience will bear this out. In addition, erasable optical disks with 3½- and 2-inch formats are also under development. Standards in this area are not as well developed as compact-disk standards.

Storage Variety

CD-ROM is the oldest and best-defined optical-storage technology. It is used primarily for publishing large amounts of information that don't require constant updating. Its major limitation, of course, is that it is a read-only medium.

Compact disks are replicated in much the same way as phonograph records. The disks are injection-molded in dies wherein all the format and data marks appear as raised ridges or hills on one of the interior faces. The original (also called the *master*) disk is written with great precision in photoresist by an argon-ion laser. After development of the master, a negative *father* disk is formed by electroplating. The father is used as a stamper to form a *mother* disk, whose negative *sons* become one face of the dies used in the injection-molding process that yields the final product. Polycarbonate is the material of choice because of its strength and durability.

WORM technology is a step beyond compact disks. You can write your own data to a WORM disk, although you can't change what you have written. WORM storage is ideal for storing custom data that is not updated often.

WORM drives feature many different designs. In some, absorption of a strong laser pulse causes local vaporization on dye-polymer media (organic films containing absorbing dyes). This forms a bubble in a thin absorbing layer above the active layer. In other designs, the laser ablates a pit in the material, exposing a highly reflective metal film below the active layer. The resultant change in reflectivity experienced by the weaker read beam is used to sense the presence or absence of a pit or bubble.

Another common active material used in WORM media is semimetallic tellurium. A strong laser pulse writes in tellurium by melting it; the attendant surface tension opens a hole (or pit) in the film, which freezes when it cools.

Other material systems are in use and under study today as the industry looks for ways to produce media less expensively. WORM disks cost about $100 in 5¼-inch format. Capacity varies from 300 to 600 megabytes per side. On 12-inch disks, capacity is typically 1 gigabyte per side. The 14-inch disks can hold more than 3 gigabytes per side.

Read/Write Technology

Figure 1 is a schematic illustration of the major components of a WORM read/write system. The left side of the figure shows the optical pathway. The read/write head contains a laser diode whose current is modulated electronically during writing to produce pulses of light. The beam of pulses travels through collimating optics, a polarizing beam splitter, and a quarter-wave plate to a focusing objective lens. The beam splitter is designed to transmit light polarized in one direction and to reflect light polarized in the perpendicular direction. The quarter-wave plate changes the polarization of the beam; two passes through the plate produce a polarization that is perpendicular to the original.

The objective lens focuses the laser beam through a transparent plastic (usually polycarbonate) substrate onto the thin (100-nanometer [nm]) recording layer. Servo signals drive a mechanical actuator that moves the objective lens to keep the beam in focus and on track. The servo signals are derived from the reflected light received at the quadrant photodetector and converted to electrical signals delivered to the controlling servo circuits.

The reflected light collected by all four elements of the quadrant detector generates the signals to be decoded by the EDAC (for error detection and correction) and modulation-decoding circuits. The reflected beam reads binary 1s and 0s according to the presence or absence of a pit, bump, or reversed magnetic domain at a particular position. Most disks have thin (0.8-μm-wide) concentric grooves, spaced 1.6 μm apart, to enable optical tracking. The laser writes and reads in the "lands" between the grooves.

New Kid on the Block

Although ideal for certain applications, CD-ROM and WORM drives are not general-purpose storage devices. The first optical storage device to earn that distinction is the erasable optical disk.

You can now purchase rewritable magneto-optical (MO) disk drives that store up to 650 megabytes of information. You can even buy optical-disk jukeboxes that typically provide 30 to 50 gigabytes of on-line storage and provide access to any file in 10 seconds or less.

Rewritable optical disk drives use the standard 5¼-inch form factor and store data on optical media housed in removable cartridges. Although access times for rewritable disks are two to six times slower than those of high-performance (17-millisecond) hard disks, data rates are comparable because the disk spins at up to 3600 revolutions per second. The media should last at least 10 years without reconditioning and provide unlimited rewrites. Currently, rewritable disk drives cost in the neighborhood of $5000 to $6000, and disk cartridges sell for about $250. These prices are steep, but you can expect them to come down as the technology matures. In fact, one manufacturer expects the prices of drives to drop by a factor of 10 by 1995.

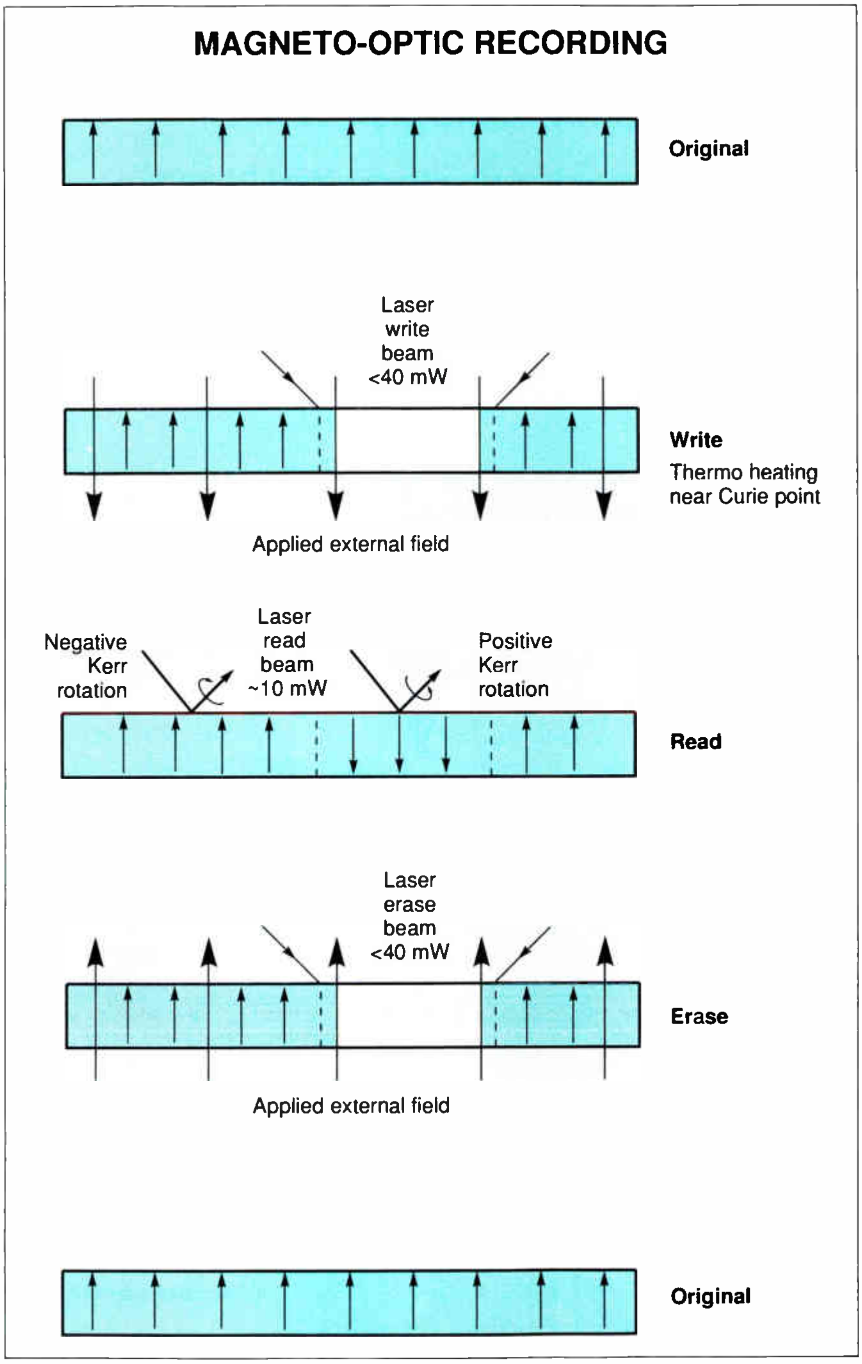

Figure 2: *In synchrony with an external magnet, the strong write pulse fixes the magnetic orientation of a spot on the recording layer. The local magnetization imparts a positive or negative Kerr rotation to the reflection of the weak read beam. The magneto-optic head detects this rotation. (Figure courtesy of Paul Y. Hu)*

Erasable optical disk drives hardly spell the end of magnetic storage. With their speed advantage, magnetic hard disks have the clear edge for large, multiuser applications, while magnetic tape is still the least expensive form of storage. For the foreseeable future, you will still need a minimum amount of fast-access storage (perhaps 90 megabytes) to hold your computer's operating system and the applications that you use frequently, as well as workspace for those applications. Rewritable optical storage is ideal if you need a lot of on-line, random-

continued

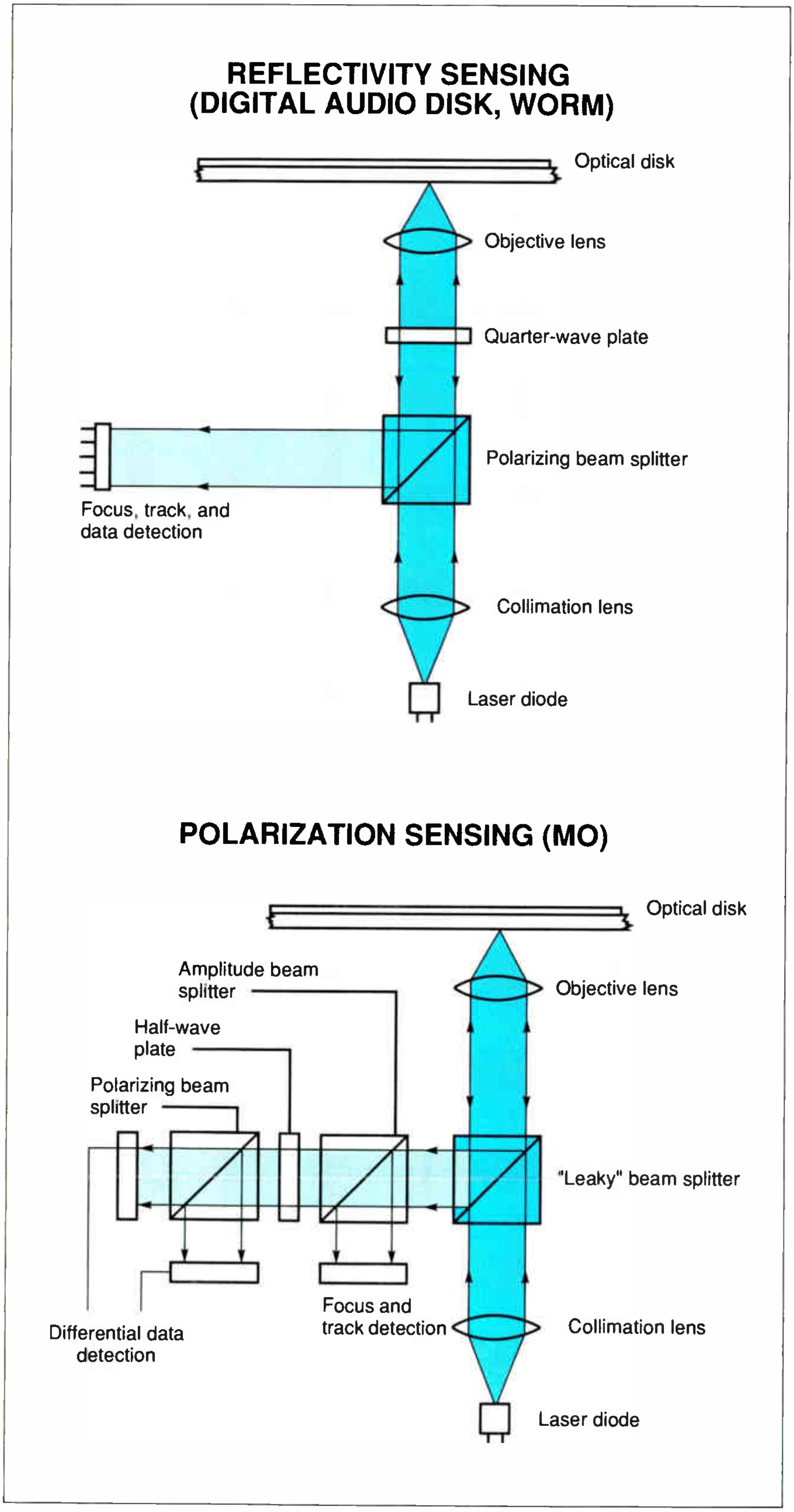

Figure 3: *The size and complexity of magneto-optic heads result in their relatively slow access times. (Figure courtesy of Paul Y. Hu)*

access storage at reasonable cost. Optical storage typically costs 25 cents per megabyte, or about 100 times less than magnetic disk storage.

Rewritable Media

Erasable disks typically have polycarbonate substrates, although some developers prefer hardened glass. With glass substrates, a layer of photopolymer, stamped with grooves and other formatting marks, covers the substrate. For polycarbonate disks, the grooves are formed in the injection-molding process that produces the substrate.

Above the grooves are three or four additional layers. One is the active recording layer, which usually consists of a rare earth/transition metal alloy such as terbium iron cobalt (TbFeCo). This layer is sandwiched between two transparent dielectric layers that provide optical enhancement of the polarization rotation as well as protection from oxygen and hydroxide ions, which would attack the metal alloy.

The active recording layer of an erasable optical disk is magnetized. The rotation of polarization of light reflected by this magnetic layer is known as the magnetic Kerr effect. Figure 2 illustrates how this effect is used in MO storage. Prior to its first use, an unwritten disk has a spatially uniform net magnetization illustrated by the upward-pointing arrows in the figure. These represent 0s at all bit positions.

To write a binary 1 at a particular location (or domain), you focus a 100-nanosecond pulse of laser light on the layer while a small magnet on the opposite side of the disk produces an external magnetic field opposite in direction to the original magnetization. The layer absorbs most of the laser pulse, which rapidly raises its temperature hundreds of degrees. At the locally high temperatures achieved, the magnetization of the layer is instantly reversed and then fixed with equally rapid cooling.

To erase a written domain, the field of the small magnet is reversed and the domain is pulsed a second time, returning the domain to its original magnetization. Note that written domains must be erased before they can be rewritten. This makes typical write times twice as long as read times.

To read a read/write disk, a weaker linearly polarized laser beam is focused on the recording layer. When reflected, this beam has its polarization rotated slightly (about 1 degree) clockwise or counterclockwise, depending on whether the local magnetization is pointing up or

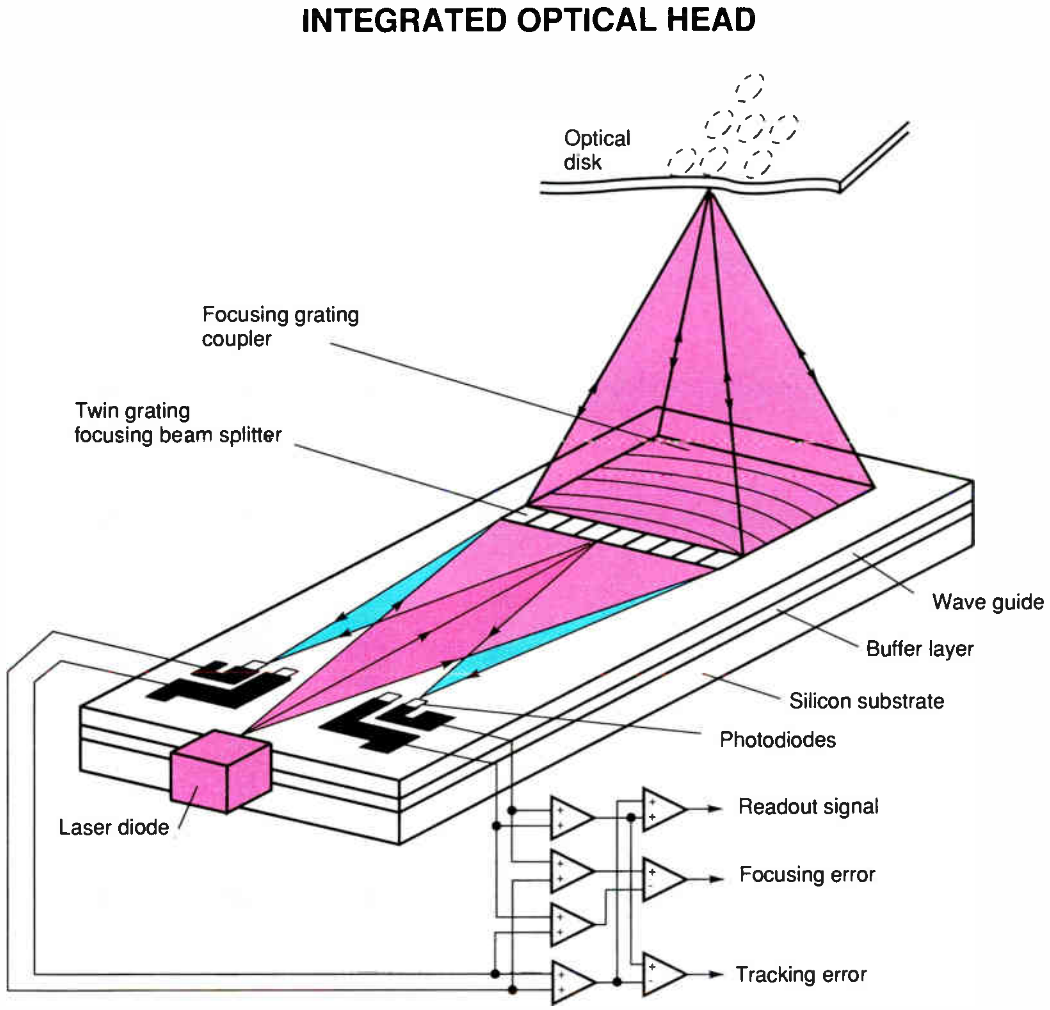

Figure 4: *Developed at Osaka University, this device is substantially less massive than conventional optical heads. Work continues to improve its resolution. (Figure courtesy of Paul Y. Hu)*

down. The direction of rotation indicates whether the bit read is a 1 or a 0.

Read/Write Heads

Most optical heads (containing the laser, beam splitter, wave plate, objective, and detectors) actually sit in a compact package below, rather than above, the disk. The head is moved from track to track by voice-coil linear actuators similar to those used in magnetic disk drives. The comparatively slow (about 100-ms) access times of optical disk drives is a consequence of the relative massiveness (100 grams) of the optical head. Research into integrated optical heads is expected to solve this problem.

Figure 3 illustrates the difference between MO heads and those used in digital-audio disk and WORM drives. In the MO head, the first beam splitter reflects all light polarized perpendicular to the page, but it transmits only about 80 percent of the orthogonal polarization, reflecting the rest. Thus, light with both polarizations is reflected to the left after interacting with the media. The second beam splitter picks off a portion of this light to provide signals for the focus and track servos. Most of the light continues to the left, passing through a half-wave plate that rotates the polarization by 45 degrees, and then through a third polarizing beam splitter to two detectors whose photocurrents are differentiated electronically. This differential detection scheme removes the comparatively large DC photocurrent common to both detectors and sums their small AC currents, whose sign (positive or negative) indicates whether the MO layer imparted positive or negative rotation to the beam.

New Media

Because the optics that are needed to detect the small Kerr rotation in MO systems are much more complicated than those used in CD-ROM and WORM heads, research continues into substances that produce larger, easier-to-detect Kerr rotations. Bismuth-doped-garnet films and metal multilayers (or superlattices) are among the substances being developed for MO recording. At present, the garnets are too grainy (or noisy) to compete with rare earth/transition metal alloys. However, because they provide larger Kerr rotation and are much less susceptible to corrosion, work continues to improve their performance.

Other promising materials for rewritable optical media include *phase-change* layers that are made of amorphous alloys

continued

of tellurium, selenium, and other elements. When heated with a focused laser pulse of appropriate power and duration, these alloys crystallize locally, forming a spot of increased optical reflectivity. A more powerful pulse of shorter duration erases (or amorphizes) the crystalline mark.

Phase-change media are attractive for rewritable applications because the optical head required is simpler than with MO drives, and the signals are stronger. The problem with most phase-change media is that only a limited number of write and erase cycles are possible before performance degrades to unacceptable levels. At least one company has apparently overcome this limitation: Matsushita Electric has announced the introduction of a commercial phase-change system in Japan. Dye-polymer media are also being developed for rewritable storage. No working products have reached the market yet.

The Future of Optical Storage

The key technologies that are driving the advances in optical recording are media, lasers, optics, the recording channel, and electronics.

In the near term, the most important subject for research into media is how to achieve direct overwrite in MO recording. Currently available media must be erased before being rewritten, creating a two-pass process. Promising areas of research involve bilayer and trilayer combinations of active media. Direct overwrite has been demonstrated with phase-change media, although so far there are no products available in North America.

Lasers and Channels

The semiconductor laser diode has been central to all advances in both communication and recording (see "Reflected Light" on page 249). These tiny devices, 200 to 300 μm on a side, deliver up to 40 milliwatts of optical power into the optical path of MO drives. The wavelength of their emissions is typically 830 nm, although 780-nm lasers are also in use.

The wavelength and the focusing power of the objective lens determine the spot size at the active layer. In today's systems, the spot size is slightly larger than one wavelength. Obviously, shorter wavelength lasers would yield greater disk capacity.

Researchers have demonstrated 670-nm lasers in the gallium indium aluminum arsenide (GaInAlAs) system, and they are attempting to make blue lasers with group II-VI semiconductors. Optical frequency-doubling and frequency-mixing devices have also been demonstrated, though not with the efficiency and compactness required for optical heads.

Surface-emitting diode lasers, and arrays of such lasers on a single chip, have been demonstrated by several laboratories. These lasers are candidates for multiple-beam optical recording, which is currently the most direct way of increasing data rates. In fact, edge-emitting arrays of four and five elements have already been demonstrated in multitrack reading and writing with a single objective lens.

Servo and channel technologies are essential to both optical and magnetic recording and continue to be advanced in both arenas, with each borrowing from the other. The optical channel presents problems not encountered in magnetic hard disks, such as burst errors associated with disk contamination during manufacture. Because marks are only about one wavelength apart on a track, and the tracks are separated by 1.6 μm, a particle of dust or dirt at the active layer can mask many contiguous bits. Thus, sophisticated modulation codes have been developed, and research continues to find better codes.

Downsized Heads

The most important area of optical research today is the optical head. At 100 grams, it is much too massive to meet the challenge of 17-ms random access. Integrated optical heads, such as the one illustrated in figure 4, may one day solve this problem.

The compact-disk head in the figure was proposed and constructed by Professor Hiroshi Nishihara and his colleagues at Osaka University in Japan. Although devices of this kind had been proposed before, this was the first functional demonstration. The device is built up on a 5-mm by 10-mm silicon chip that has an oxidized upper surface. A thin dielectric layer of a higher refractive index is deposited on the upper layer and serves as an optical wave guide. It confines the diode laser light introduced at its edge to within its walls and their immediate surroundings.

The laser beam expands laterally as it propagates toward a focusing grating coupler. The shallow curved grooves of the FGC are spaced closer together along its length. This changes the direction of the light radiated from them and focuses the light at the disk. Reflected light from the disk is diffracted back into the wave guide. There, a second wave-guide grating diverts it to tracking, focusing, and signal detectors, built up on the silicon substrate by conventional semiconductor processing techniques. Although the device works, the smallest spot size that has been achieved thus far has been 2 μm—too large to read a compact disk.

Nishihara's group has also demonstrated a partially integrated MO head. Light reflected from a disk is launched into adjacent wave guides by three different FGCs and sent to separate detectors. The objective lens that sends light to the disk and the laser itself were not integrated, however.

The seminal work of the Nishihara group has provoked related studies in many laboratories. Applications of integrated optics to communications systems have been under development since the early 1970s. Thus, much of the wave-guide technology needed for integrated optical heads is already available, as are grating couplers, a common component in any guided-wave laboratory. However, focusing grating couplers that are efficient and yield high-quality beams with good polarization properties need to be developed or appropriately combined with other "micro-optic" elements to yield the necessary quality. Additionally, gratings are very sensitive to wavelength shifts. Diode laser manufacturers cannot control the wavelength of peak emission accurately. Thus, techniques for compensating wavelength shift must be developed.

While there is much research still to be done, it is likely that you will one day see optical drives with multiple disks and multiple integrated optical heads, incorporating multiple lasers. The prospects of matching, and even exceeding, the performance of today's hard disks are excellent. Of course, magnetic technology will improve as well. You can expect to see both technologies working side by side in the foreseeable future. ■

ACKNOWLEDGMENT
We would like to thank Paul Y. Hu for the use of the figures. Paul is an adjunct professor in the Optical Sciences Center at the University of Arizona and a senior engineer at IBM's general products division in Tucson, Arizona.

James J. Burke is a professor in the Optical Sciences Center at the University of Arizona in Tucson and director of the Optical Data Storage Center there. He has a Ph.D. in optical sciences from the University of Arizona and can be reached on BIX c/o "editors." Bob Ryan is a BYTE technical editor. He can be reached on BIX as "b.ryan."

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Circle 318 on Reader Service Card

Read/Write Optical Subsystems

Unlike CD-ROM, WORMs and erasable optical disks let you write and store massive amounts of your own data. The following is a list of WORM- and erasable disk-drive systems available to end users (as opposed to OEMs). Note that the capacity given combines the capacities of both sides of the media. For the amount of storage on-line at one time, divide the capacity by 2.

Advanced Graphic
Applications, Inc.
90 Fifth Ave.
New York, NY 10011
(212) 337-4200
DISCUS Rewritable
DR650-SE $6495
650-megabyte erasable optical disk system for the AT and PS/2s.
Inquiry 1181.

Alphatronics, Inc.
P.O. Box 13687
Research Triangle Park
Durham, NC 27713
(919) 544-0001
Inspire Desktop
Dual Drive $13,900
1300-megabyte erasable optical disk drive for the AT. Also available for DEC and Sun systems.
Inspire Desktop
Single Drive $7900
650-megabyte erasable optical disk drive for the AT. Also available for DEC and Sun systems.
Inquiry 1182.

Aquidneck Systems
International, Inc.
650 Ten Rod Rd.
North Kingston, RI 02852
(401) 295-2691
Optical Archiving
System .... from $23,000
Sophisticated read/write system capable of storing up to 1 terabyte of data. Supports many mainframes, minicomputers, and workstations.
Inquiry 1183.

Computer Upgrade Corp.
2910 East La Palma Ave.,
Suite A
Anaheim, CA 92806
(714) 630-3457
Optical Storage Subsystems
5¼-inch drives (450 to 1200 megabytes) .... from $1595
12-inch drives (1000 to 6000 megabytes) .... from $5995
Jukebox subsystems (25 to 141 platters per unit)..... from $15,000
Complete line of optical storage systems for Macintosh, Apollo, DEC, Data General, IBM, Perkin/Elmer, and Sun computers.
Inquiry 1184.

Corel Systems Corp.
1600 Carling Ave.,
Suite 190
Ottawa, Ontario, Canada K1Z 8R7
(613) 728-8200
Corel 400
IBM PC and Macintosh version $2895
Novell NetWare version $3995
400-megabyte SCSI WORM drive subsystem.
Corel 650
IBM PC and Macintosh version $3975
Novell NetWare version $4995
654-megabyte SCSI WORM drive subsystem.
Corel 800 .... $3645
800-megabyte SCSI WORM drive subsystem for the IBM PC and Macintosh.
Corel 940 .... $3845
940-megabyte SCSI WORM drive subsystem for the IBM PC and Macintosh.
Inquiry 1185.

Delta Microsystems, Inc.
5039 Preston Ave.
Livermore, CA 94550
(415) 449-6881
SCSI WORM
Subsystem .... from $6000
567-megabyte to 2000-megabyte optical disk drives for Sun systems.
Inquiry 1186.

Deltaic Systems
1977 O'Toole Ave.,
Suite B206
San Jose, CA 95131
(408) 954-1055
OptiServer 600 .... $4499
594-megabyte SCSI erasable optical disk drive for the Macintosh. Conforms to ISO standard.
WORMServer 1000 .... $3599
940-megabyte SCSI WORM subsystem for the Macintosh. Also uses 400-megabyte disks.
Inquiry 1187.

Information Storage, Inc.
2768 Janitell Rd.
Colorado Springs, CO 80906
(719) 579-0460
ISi 525GB $6288
1280-megabyte internal WORM drive subsystem; external version also available for the AT.
Inquiry 1188.

Laserdrive Ltd.
1101 Space Park Dr.
Santa Clara, CA 95054
(408) 970-3600
810-111 (DOS version) $5495
820-011 (Macintosh version).. $5995
810-megabyte WORM drive subsystem.
Inquiry 1189.

Maximum Storage, Inc.
5025 Centennial Blvd.
Colorado Springs, CO 80919
(719) 531-6888
APX-4200 .... $4450
760-megabyte WORM optical disk drive subsystem for DOS machines.
Inquiry 1190.

Micro Design International, Inc.
6985 University Blvd.
Winter Park, FL 32792
(407) 677-8333
LaserBank 400 .... $2995
400-megabyte WORM drive system for DOS systems. Also available for Xenix and Unix.
LaserBank 940 .... $4095
940-megabyte SCSI WORM drive system for DOS systems. Also available for Xenix and Unix systems.
LaserBank 600 R $6995
600-megabyte erasable optical disk drive for DOS systems. Also available running under Xenix and Novell NetWare.
Inquiry 1191.

Mitsubishi Electronics
America, Inc.
Computer Peripherals Division
991 Knox St.
Torrance, CA 90502
(213) 217-5732
MW-5D1 .... $3400
600-megabyte internal SCSI WORM drive system for the IBM PC.
MW-5U1 .... $4300
600-megabyte external SCSI WORM drive system for the IBM PC.
Inquiry 1192.

N/Hance Systems
908 Providence Hwy.
Dedham, MA 02062
(617) 461-1970

N/Hance 525
Internal version $2750
External version $2950
240-megabyte WORM drive system for DOS systems includes interface, driver, and Text.Scan software.

N/Hance 565
DOS versions:
Internal $4295
External $4495
Xenix versions:
Internal $4975
External $4995
654-megabyte SCSI WORM drive system with host adapter, driver, Text.Scan software, and Write Once File System (WOFS) software.

N/Hance 5120
PC versions:
Internal $6188
External $6388
2560-megabyte double drive.......................... $11,695
Xenix versions:
External $8195
2560-megabyte double drive.......................... $13,495
1280-megabyte WORM drive with interface and driver.
Inquiry 1193.

Online Computer Systems, Inc.
20251 Century Blvd.
Germantown, MD 20874
(301) 428-3700

MDU ....from $6000
Multimedia storage unit for DOS systems includes 400-megabyte WORM drive plus CD-ROM, hard disks, tape backup, and SCSI connector. Also supports OS/2, Unix, and VAX/VMS.
Inquiry 1194.

Panasonic Industrial Co.
2 Panasonic Way
Secaucus, NJ 07094
(201) 348-7000

LF-5010.......................... $3299
940-megabyte external SCSI WORM drive system for the IBM PC and the Macintosh.
LF-5014.......................... $2999
940-megabyte internal SCSI WORM drive system for the IBM PC.
Inquiry 1195.

Peripheral Land, Inc.
47421 Bayside Pkwy.
Fremont, CA 94538
(415) 657-2211

Infinity Optical................ $5695
635-megabyte erasable optical disk drive for the Macintosh.
Infinity Optical 1.2 .... $11,995
1270-megabyte erasable optical disk subsystem (two drives).
Inquiry 1196.

Pioneer Communications of America, Inc.
Optical Memory Products Division
Sherbrooke Plaza
600 East Crescent Ave.
Upper Saddle River, NJ 07458
(201) 327-6400

DD-S5001
PC version..................... $3895
Macintosh version............ $3695
654-megabyte WORM drive subsystem.
Inquiry 1197.

RACET computes Ltd.
3150 East Birch St.
Brea, CA 92621
(714) 579-1725

Cosmos 600
AT version..................... $5690
Macintosh version............ $5190
594-megabyte erasable optical disk subsystem.
Inquiry 1198.

Storage Dimensions
2145 Hamilton Ave.
San Jose, CA 95125
(408) 879-0300

LaserStor
AT and PS/2 version $4495
Macintosh version............ $4995
786-megabyte WORM drive subsystem.
LaserStor Erasable Optical........................... $7995
876-megabyte SCSI erasable optical disk drive system for the AT, PS/2s, Macintosh, and Novell NetWare. Also uses 574-megabyte ISO-compatible cartridge.
Inquiry 1199.

Sumo Systems
1580 Old Oakland Rd.,
Suite C103
San Jose, CA 95131
(408) 453-5744

RSSM600-B..................... $4500
594-megabyte erasable optical disk system for the Macintosh.
Inquiry 1200.

Summus Computer Systems
17171 Park Row,
Suite 300
Houston, TX 77084
(713) 492-6611

Lightdisk-650
AT version..................... $6495
Macintosh version............ $5495
594-megabyte erasable optical disk system. Also available for DEC and Sun machines.
Inquiry 980.

United Systems Co.
14701-B Myford Rd.
Tustin, CA 92680
(714) 832-3613

Spark L1200.................$19,000
2000-megabyte WORM storage system. Includes a powerful proprietary operating system that works in conjunction with MS-DOS.
Inquiry 981.

This resource guide is intended to provide a reasonable cross-section of available products, companies, and services; due to space limitations, we cannot list all companies and products. Inclusion in the resource guide should not be taken as a BYTE endorsement or recommendation. Likewise, omission from the guide should not be taken negatively. The information here was believed to be accurate at the time of writing, but BYTE cannot be responsible for omissions, errors, or changes that occur after compilation of the guide.

THE 25TH BIRTHDAY OF BASIC

Everybody's first language is a quarter century old: You've come a long way, BASIC

Bill Gates

Since the first program ran on an English-built computer in 1948, computing has evolved by several orders of magnitude. In just 15 years, personal computers have grown from 8-bit, 4K-byte toys to powerful 32-bit, 16-megabyte tools for science and industry.

Amid all this growth in hardware, the BASIC language has quietly turned 25 years old, and the BASIC interpreter that opened up the microcomputer to millions of people has entered its fifteenth year.

BASIC didn't become the best-known and most accessible computer language simply because it comes free with every machine. BASIC's strengths—the simplicity of using an interpreter, its powerful string handling, the richness of the language, its English-like keywords and syntax, and the freedom it gives programmers to experiment—make it the ideal way for computer novices to explore the intricacies of their computers.

During this milestone year for BASIC, you can see how it may evolve by looking at the technology of operating systems like OS/2 and the promise of object-oriented programming.

BASIC was born out of a need to give nontechnical people a simple way to interact with a computer. In 1962, a math professor at Dartmouth College, Thomas Kurtz, proposed to the department chairman, John Kemeny, the radical idea that all Dartmouth students should learn about computers during their four-year stay. But the batch-oriented computers of the day made that prospect impossible, since it often took days to find out if a simple program would compile properly. Even then, the program could only calculate a result and return an answer; the person who wrote the program never actually saw it run.

Kemeny and Kurtz, expanding on research going on at MIT and Bell Labs, built a time-sharing operating system for a new computer that Dartmouth was about to receive. In the process, they decided that giving students a way to share the computer's hardware was of little use without a simple language for talking with the machine. FORTRAN and ALGOL didn't fill the bill for ease of use, so they created the Beginner's All-purpose Symbolic Instruction Code as a simplified blend of the best of FORTRAN and ALGOL.

On May 1, 1964, Dartmouth students, greeted by the now famous READY> prompt on their teletype terminals, could write simple programs and send them off to be compiled and run. Listing 1 shows a simple program (a multiplication table) written in that first BASIC. Kemeny and Kurtz recount the birth of BASIC in their book *Back to BASIC* (Addison-Wesley, 1985).

And Then There Were Micros

The first microcomputers, sporting very small memories, came on the scene in 1975 from companies like MITS and Southwest Technical Products. These machines understood only machine language. Paul Allen and I sensed an opportunity and wrote a version of BASIC to run in those small memory spaces. Our first BASIC for the MITS Altair allowed a user to run programs on a 4K-byte machine. Memory was so precious that we even replaced the READY> prompt with OK> to save a few bytes. We built this BASIC as an interpreter.

Memory constraints partly guided our decision to implement BASIC as an interpreter. But another factor was our fascination with interpreters, and the immediacy and ease of use they give to the programming art. An interpreter lets a programmer tell the computer to perform a job, and then the computer gives immediate feedback and results, including the reporting of errors. This immediacy comes from the interpreter's being built as part of the language, not as a separate program like a compiler. First-time users would find working with a compiler difficult.

Drawing on experience I had obtained writing a BASIC interpreter for a PDP-8 while in high school, Paul and I made our original microcomputer BASIC a single-representation interpreter. This means that rather than storing the exact source code in text form, we translated it into a more compact form because of the memory constraints we faced.

We did tricks to let the programmer see his or her program

continued

ILLUSTRATION: RANDY LYHUS © 1989

exactly as he or she keyed it in while executing the program at a reasonable speed. Using the lower values of a byte and the upper 128 ASCII values to tokenize BASIC keywords was an innovation in that interpreter. We also coined the short commands TRON and TROFF to turn on and off BASIC's earliest built-in debugging tool, a trace facility. Fitting the language's reserved words, error messages, and floating-point library to run programs in a 4K-byte machine required a lot of tricks—it's still my favorite piece of code because it is so refined.

We chose to write a BASIC interpreter for several reasons. First, BASIC was simple enough that we thought we could squeeze it, plus user programs, into 4K bytes. We also liked being able to write a meaningful one-line program in BASIC; with other languages, you had so many variable and environment definitions to worry about, you had to write several lines of code just to print "hello" on the screen. And we liked BASIC's powerful variable-length string-handling functions.

Listing 1: *The 1964 BASIC had no INPUT statement. Instead, you had to assign data to a variable with the LET or READ DATA statements.*

```
10 REM 1964 BASIC
20 LET N = 355/113
30 PRINT "MULTIPLICATION TABLE FOR",N
40 FOR I = 1 TO 10
50 PRINT I, N * I
60 NEXT I
70 PRINT "---------------"
80 END
```

Listing 2: *The 1977 8K-byte BASIC had longer variable names, the INPUT statement, strings, and the IF. . . GOTO statement. This is a more flexible version of the program in listing 1.*

```
10 REM 1977 8K BASIC
15 PRINT "ENTER NUMBER FOR MULTIPLICATION TABLE"
20 INPUT NUMBER
25 INPUT "ENTER NUMBER OF LINES"; LINES
26 IF LINES <1 GOTO 120>
30 PRINT "MULTIPLICATION TABLE FOR",NUMBER
40 FOR I = 1 TO LINES
50 PRINT I, NUMBER * I
60 NEXT I
70 PRINT "---------------"
80 PRINT "DO YOU WANT ANOTHER Y/N";
90 INPUT C$
100 IF C$ = "Y" GOTO 15
115 REM
120 REM ERROR HANDLING
130 PRINT "WRONG NUMBER OF LINES"
140 END
```

Listing 3: *The 1985 Microsoft QuickBASIC. It and other BASICs of the period eliminated line numbers and added subroutines and IF. . . THEN. . . ELSE statements.*

```
INPUT "File to be searched";F$
INPUT "Pattern to search for";P$
OPEN F$ FOR INPUT AS #1
WHILE NOT EOF
   LINE INPUT #1, TEST$
   CALL LINESEARCH(TEST$,P$)
WEND

SUB LINESEARCH(TEST,P$) STATIC
    STATIC NUM
    NUM = NUM = 1
    X = INSTR(TEST$,P$)
    IF X = 0 THEN
       EXIT SUB
    ELSEIF X > 0 THEN
       PRINT "Line #";NUM;":";TEST$
    END IF
END SUB
```

Why Use BASIC?

We convinced the makers of the early microcomputers that they needed BASIC in their machines to let people use them. Otherwise, you could turn on the machine, but you couldn't do much with it. And until disk operating systems came along in about 1979, BASIC was the only way most people could use a personal computer. Our BASIC caught on because we encouraged people to write books about BASIC programming that contained lots of source code listings. We also promoted the idea of people writing programs in our BASIC and then selling or giving away those programs.

Other people were writing BASICs at that time: Li Chen Wang (Tiny BASIC), Steve Leininger (Radio Shack Level 1 BASIC), Steve Wozniak (Apple Integer BASIC), and Gordon Eubanks (BASICe and CBASIC). But Microsoft BASIC eventually appeared in the ROMs of over 50 types of machines and became a de facto standard.

That early BASIC was primitive compared to today's language. It forced you to use only two-letter variable names and required line numbers (see listing 2). But it proved to be an acceptable way to create useful programs for computers. It gave you instant feedback as you wrote a program, and its string-handling features let people write fairly sophisticated text-oriented applications. We invented new BASIC verbs like PEEK and POKE, and INP and OUT, to let people get at the resources of the machine. We devised a way to let programmers call machine language routines from BASIC so they could make critical parts of their programs faster.

Interpreters can be extended quite easily, so we frequently added new features to BASIC. We developed the music and graphics-string macro languages that used the verbs PLAY and DRAW. Many features that ended up in GWBASIC (short for Gee Whiz) came from our experience writing interpreters for Japanese machines.

BASIC hit a plateau when GWBASIC was put into the IBM PC ROM. Without IBM's updating the ROM, it was hard to popularize BASIC extensions beyond the interpreter. This BASIC became extremely popular, of course, and even today I'm amazed at what a high percentage of PC users have experimented with that BASIC because it is so simple to learn and use.

When BASIC faltered on the plateau of being an IBM PC-compatible standard, we created QuickBASIC. Other companies were extending BASIC, too—for example, BASIC's inventors, Kemeny and Kurtz, with True BASIC.

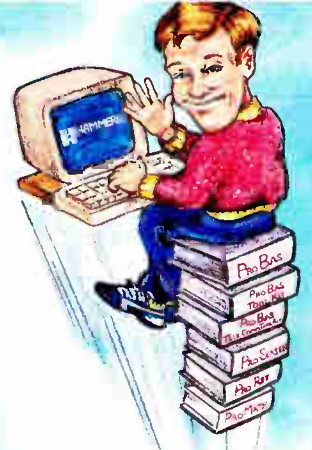
Not So Basic

When I show programmers the BASIC I use today, they say something like, "That looks a lot like Pascal." People who think of BASIC as the IBM PC's BASICA are surprised that it doesn't have to be a line-oriented language with little structure. BASIC has become very modern since 1983 (see listing 3).

In the mid-1980s, BASIC improved on three fronts: as a language, with the addition of long variable and label names, record structures, and better block-structuring tools; as an environment, with a built-in editor, debugger, and compile-run facility; and as a compiled language, with faster response in the classic compile/debug/edit/compile cycle while generating fast, high-quality code. BASIC also gained the ability to run

continued

~~Six~~ ~~Five~~ Seven easy ways to boost your BASIC



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recursive routines, to handle sophisticated structures such as B-trees, and to deal better with graphics.

About this time, BASIC became more structured, with the addition of DO WHILE, WHILE...WEND, DO UNTIL, LOOP WHILE, and LOOP UNTIL loops, and SELECT CASE constructs. BASIC today has facilities that permit creating data structures as rich as those of C or Pascal. BASIC also shed the

That early BASIC was primitive compared to today's BASIC.

shackles of 64K-byte limits on program size; today's BASIC programs are limited only by memory, and even individual arrays can be up to the limits of memory in size.

You can also use long (32-bit) integers in your programs. Record structures added the capability to let you define your own data structures, combining many different individual data types, such as strings and numbers.

The environment for BASIC programming has changed, too. In QuickBASIC 4.0 and 4.5, for instance, a built-in full-screen editor with automatic syntax editing, a built-in debugger, and context-sensitive help makes the program-creation process as fast and easy as possible. Borland also integrated a full-screen editor into Turbo Basic.

Another important change in the modern BASICs was a move from interpreters back to compilers: Indeed, Dartmouth BASIC has remained a compiled language since its inception. BASIC compilers for microcomputers appeared soon after disk operating systems became available, and were made possible, in part, by the availability of up to 64K bytes of memory.

These compilers included Microsoft products and Digital Research's CBASIC-86 compiler. Later, Better BASIC, Quick-BASIC, True BASIC, ZBasic, and Turbo Basic were developed. But the major move to compilers needed to be made without sacrificing the instant feedback and quick detection of errors, features that made the BASIC interpreter so successful.

Advancements in compiler technology enabled the development of a BASIC compiler that gave the appearance of an interpreter, thus offering the best of both worlds. Single-pass compilers that could compile first hundreds—and then thousands—of lines of code in just a few seconds gave BASIC the appearance of an interpreter but let programs execute faster.

Later, we invented an in-memory scheme combining the features of an interpreter and a compiler. It uses a special intermediate threaded pseudocode that, when combined with an environment like the QuickBASIC editor, lets you write, debug, and change the code just like in an interpreter. When you are ready, you can compile the finished product to get maximum speed and compact size in an executable file.

Compiling BASIC also made it easier to call routines written in other languages from within BASIC. Because the compiler generates standard intermediate .OBJ files, you can link C or FORTRAN .OBJ files with your BASIC .OBJ files and call

continued

those "foreign" language routines from within your BASIC program.

With these improvements in compiler technology, BASIC's longtime reputation as a slowly executing language fell by the wayside. Today, many popular commercial applications are written in BASIC. For example, there's a speaker-design program called AccoustaCADD, a radio station playlist manager called Music Scan, and even a program for molecular biologists called DNA Inspector. Modern compiled BASIC programs run as fast as programs compiled in Pascal or C.

I'm still a big fan of BASIC. It handles many of the overhead tasks that other languages force you to deal with, thereby unleashing your programming creativity. I have challenged programmers to write code to solve any problem using any tool they choose; I wager that I can write the same program faster using QuickBASIC. In fact, there is a joke around Microsoft that says when an application is falling behind schedule, "Just give it to Bill and he'll write it in BASIC over the weekend."

Still, as powerful as BASIC is today, there are ways to make it even better.

The BASIC Clairvoyant

Even though BASIC gives you great freedom for writing programs, it still forces you to think procedurally; your programs become a series of linked, step-by-step procedures to perform certain actions. Programming this way becomes an exercise in project management: First do this, then do that if something else happens, and so on.

As programs become more complex, these "projects" get harder to manage. Structured programming concepts deal with this complexity by encouraging programmers to break up code into small chunks, and then tie the chunks together with the unfortunately error-prone convention of function calls within, and across, module and file boundaries. Object-oriented programming puts a new twist on that idea: Make each program chunk a self-contained package of data and the procedures for manipulating that data, and then have the chunks send and receive messages to interact with other chunks.

This scheme provides a "black-box" mentality for program pieces—the pieces become objects whose internal complexity stays hidden from other objects. But why do you need to think of programs as collections of objects?

The visual environments that are used on computers today give a clue as to why thinking about program objects is important and different. In a visual environment, you choose an action or event after you choose the data that is the target of the action or event. For example, `delete character`, `delete word`, `delete paragraph`, and `delete page` are simply one command applied to different objects. You must choose the object—a character, word, paragraph, or page—before you select the command `delete`.

Object-oriented design techniques package data and the methods of manipulating that data together: The package becomes an object. If you want an object to do things that it doesn't currently know how to do, you create a new object that inherits the capabilities of the old object and then add the new capabilities you want to define. In traditional procedural programming, you set up the action first and then identify the data and supervise every step in the action's manipulation of that data.

Object-oriented programming will influence the development of all languages, including BASIC, over the next several years. Objects contain both code and data, and they manage their own behavior while hiding their internal complexity.

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Objects interact with other objects by passing messages back and forth. That way, any object can be changed without affecting other objects. Any programmer can create an object that can interact with any other object; all the programmer has to know is the message-passing syntax.

To adapt to this object-oriented emphasis in programming, BASIC will need the ability to create and manipulate classes and subclasses, which are the principal data abstraction devices of object-oriented programming. BASIC will also need a visual component. After all, the best way to design a form is to draw the form, not write code to reproduce it. With a mouse and a palette of predrawn graphics images, you should be able to combine lines, boxes, and buttons interactively on a screen to design a form for a program. That kind of interactive design of objects should also let you attach to or combine your creations within a program.

Future versions of BASIC will increasingly provide support for this kind of programming. The programs will look different from the BASIC we're used to. A visual BASIC program will be a mixture of code, programmer-written objects, and visually specified objects. With separate windows, you would be able to edit both the visual and code parts of the program.

HyperCard provides an interesting example of this combination of visual and more standard procedural programming. The screen display of the card, with its buttons and display areas, provides the visual field; the script language, HyperTalk, lets you create procedures that relate to the card and the information that the card links with. Although HyperCard is only a partial implementation of object-oriented programming, it forms an understandable intermediate step between procedural and object-level programming.

Another major change in BASIC's future will be its universality. This change will result from BASIC's becoming part of the overall computing environment. BASIC may soon become the equivalent of today's MS-DOS command interpreter, COMMAND.COM. If this happens, BASIC will play a role similar to the one it played in the earliest personal computers—as a universal "macro" language through which users interact with their computers and all the applications they run.

A universal BASIC would come in different flavors. One flavor would serve as a central control language for the computing environment. As an environment control tool, BASIC would be a command-line adjunct to a visual user interface. Another flavor would serve as an embedded language within application programs. Embedded BASIC would allow power users to embellish the performance of their applications, as Lotus 1-2-3 users do today, without having to learn a new macro language for each application they use.

You would be able to use BASIC syntax to tell your application programs to perform their various functions in the order you want them performed. For example, if you needed a certain report each month, you'd be able to write a short BASIC program that tells the application to gather the relevant data, format it properly, and have it waiting for you at the appointed hour. BASIC can provide this power while remaining easy to learn and use. These kinds of changes will keep BASIC vibrant for a long time.

Perpetually Young

The next 25 years in BASIC's life will probably be even more exciting than the first 25. BASIC's development has mirrored the explosive growth of the personal computer industry: When the hardware was weak, BASIC was pretty cramped, too. The rapid improvements in hardware in the last 15 years have been matched by the growth of BASIC in both power and flexibility. If you haven't looked at BASIC in the last few years, you'll be surprised by how it's changed. Compare listings 1, 2, and 3 to see the evolution of BASIC from 1964 through 1985.

In the late 1970s, when C started becoming very popular, many people predicted the demise of the COBOL and FORTRAN languages. Pascal was supposed to sound the death knell for BASIC. But all these languages continue to survive. I believe that in the case of BASIC, the language is flourishing. If BASIC becomes a universal macro language, as I think it will, it may outlive all the procedural languages. BASIC may, in fact, outlive us all. ■

Bill Gates is chairman and CEO of Microsoft Corp. in Bellevue, Washington. He cofounded the company in 1975 with Paul Allen. He can be reached on BIX c/o "editors."

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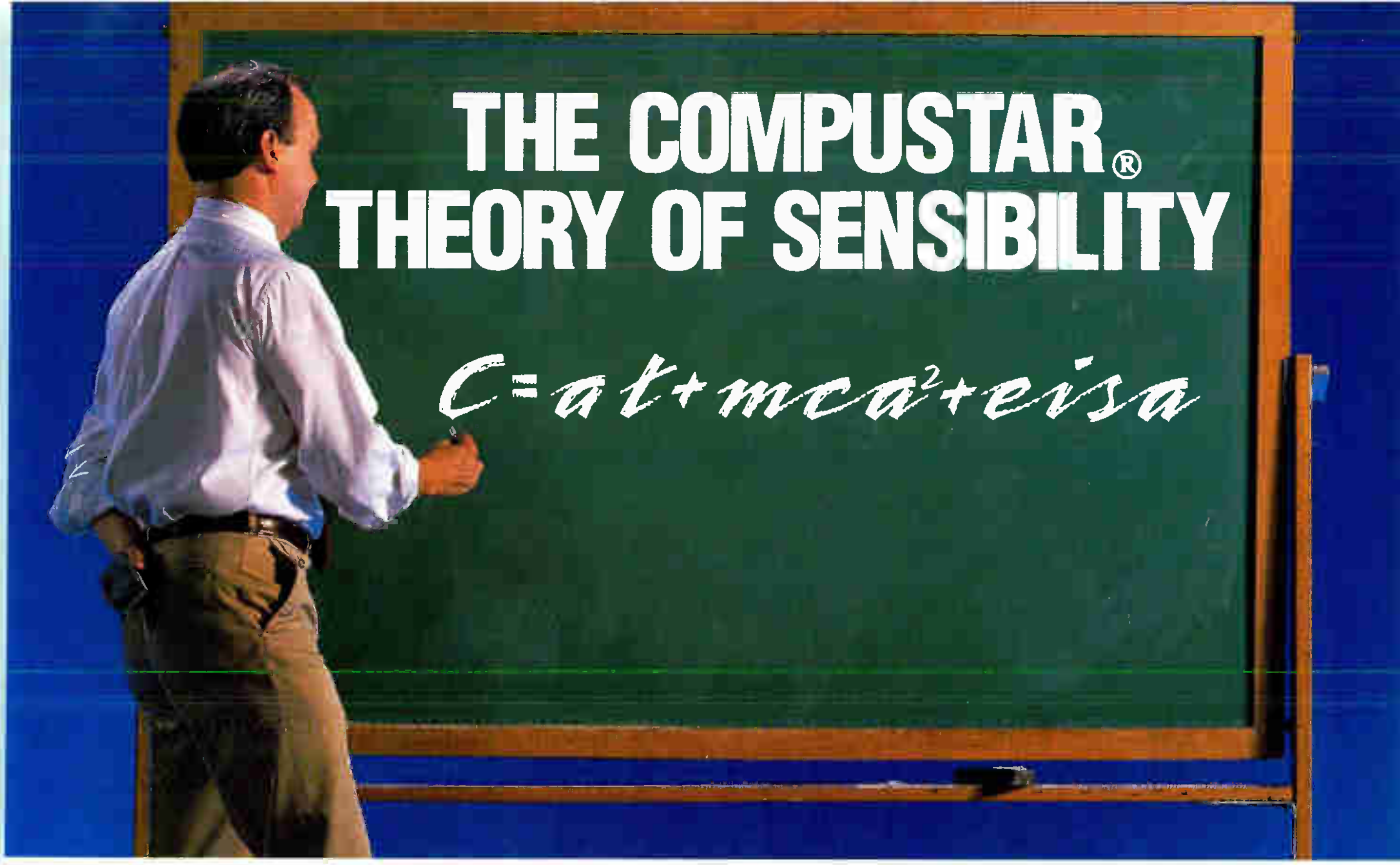

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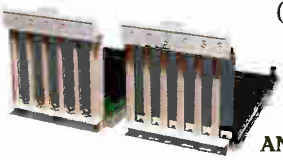

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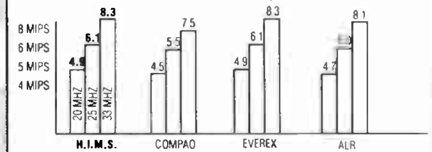

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HIMS TECHNOLOGIES

OCCAM II

Companion and counterpart of the INMOS transputer, the Occam II programming language is designed for parallel processing

Dick Pountain

In the fourteenth century, the English philosopher/monk William of Occam gave science his famous "Occam's razor" principle, which states that assumptions should be kept to the minimum (or the simplest explanation is best). The literal translation of the Latin *Entia non sunt multiplicanda praeter necessitatem* is "Entities should not be multiplied beyond necessity," which is still good advice even now in the era of floating-point coprocessors.

In the 1980s, INMOS introduced the transputer, a high-speed microprocessor designed for parallel processing. With it came Occam, the programming language designed especially for parallel programming on the transputer. Occam II is the latest version of Occam.

An Occam Machine

INMOS developed Occam and the transputer together in a way that few hardware/software combinations have been developed before. The transputer's hardware features (e.g., the on-chip serial links) were chosen to support the Occam model of concurrency, and the instruction set was devised to optimize execution of Occam programs. In turn, the features of the Occam language compiler were shaped by the hardware operations and performance, given the state of VLSI technology in the early 1980s. Although the transputer is perfectly capable of running programs written in C, FORTRAN, Pascal, or assembly language, it is an "Occam machine" in a real sense. To be more precise, the transputer embodies in hardware the Occam model of computation.

The Occam Philosophy

Since their inception in the 1940s, digital computers have been rather "introverted" entities. John von Neumann's great insight that a single memory space can hold both the data and the program that manipulates the data has governed the design of all computers to this day and, indirectly, of programming languages as well. A digital computer carries out its processing activity in the small enclosed world of its RAM space. The outside world impinges only by exceptional means. The single-closed-world concept is the essential simplification that has allowed the science of computing to flourish so remarkably over the last 40 years. Only now is the computing community in a position to risk stepping away from it.

The demand for computing power, driven by applications like weather forecasting, real-time three-dimensional graphics, and numerical simulations, is growing exponentially. The pursuit of this extra power has made it clear that the basic von Neumann concept can be pushed only so far. The idea of a single (faster and faster) processor talking to a single (larger and larger) memory no longer has validity; the processor spends more time fetching instructions and data than it does processing. The speed of the bus that connects the memory and the processor has become a crucial bottleneck. Ever more elaborate layers of caching only postpone the inevitable crunch. It is generally agreed that the way to greater power and performance involves splitting up computations so they run on more than one processor concurrently—in other words, parallel processing. (See the In Depth section of the November 1988 BYTE.)

Unfortunately, while the von Neumann architecture has allowed the industry to make enormous strides in hardware optimization, it has also restricted the evolution of programming languages for distributed networks of processors. Conventional programming languages assume that the data is stored in main memory (if the data is stored externally, on magnetic disk, it must be brought into memory before it can be used). Languages like C and Modula-2 don't even have I/O instructions in their core language. They implement I/O operations as separate library routines. I/O instructions tend to be different in kind from the arithmetic and logical instructions that perform the processing. They frequently display complicated, ad hoc semantics imposed by the idiosyncrasies of communicating with external devices. What's more, the instructions for disk I/O are

continued

often different from those for screen I/O or serial port I/O. Consider, for example, the contortions involved in establishing an RS-232C link in BASICA.

The von Neumann architecture has also constrained programming language design in another way. It assumes a single processor sequentially executing a single list of instructions from the main memory. The most widely used programming languages display this assumption in their design fundamentals. Some languages, such as Modula-2, have added features to support concurrent execution, but, except perhaps in the case of Ada, these features feel more like optional extensions than integral parts of the language. When writing a concurrent program in these languages, the programmer often must become involved in the detailed mechanism of process synchronization.

Interprocess Communication and Concurrent Execution

In Occam the concepts of communication and concurrent execution are built into the core of the language itself rather than tacked on as afterthoughts. David May designed Occam at the INMOS research center in Bristol, England. Professor Tony Hoare of Oxford University greatly influenced the design of the Occam channel through his seminal paper "Communicating Sequential Processes" (*Communications of the ACM,* 1978). The key idea of CSP is that parallel computations can be implemented by a number of purely sequential von Neumann machines communicating with each other over a network of self-synchronizing channels.

The CSP idea infuses both the transputer hardware and the Occam language. The transputer acts as a whole computer-on-a-chip, complete with memory and four fast serial communication links. A network can be constructed by joining the links of several chips together. These links run concurrently with the main processor and have built-in hardware handshaking for synchronization. The transputer hardware also features an efficient time-slicing process scheduler that lets multiple processes run on the same chip. As I'll show below, it is crucial to the design that the same multiple processes can run *either* on multiple transputers *or* on a single one. (See "T800 and Counting," November 1988 BYTE, for more information on transputer hardware.)

In Occam, the abstract concepts of a *process* and a *channel* are equivalent to the elements of the CSP model; that is, the programmer can build closely linked multiprocessor networks by linking processes with channels. Occam channels support the underlying handshaking mechanism of the transputer *links* in a way that is totally transparent to the programmer. The crucial point is that an Occam program makes no initial assumptions about the actual hardware network it will run on. An Occam channel can eventually be implemented either as a real transputer link joining the separate memory spaces of two processors or as a shared memory location on the same processor without altering the program's logic. When coding a parallel-process algorithm, you can concentrate solely on getting the logic correct and ignore hardware issues.

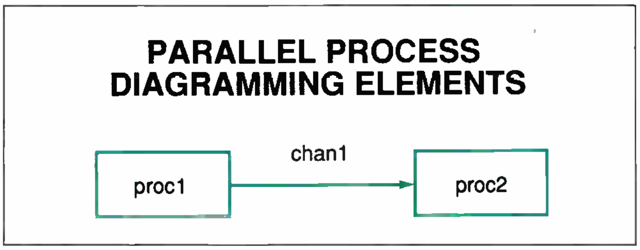

Figure 1: *A process diagram of the simple program structure where* proc1 *communicates to* proc2 *through* chan1.

Multiprocessor development can actually take place on a single transputer. When the program logic is correct, you can map it onto a real network of transputers (of sufficient number to achieve the required performance) without altering its logical behavior. This intimate connection between Occam and the transputer hardware has given rise to much confusion about how "high-level" a language Occam is meant to be. I have devoted a section below to this issue.

Processes and Channels

The fundamental program element in Occam is the *process*. By definition, "a process starts, performs actions, and then terminates." This sounds very much like the definition of any computer program, but it forces you to think about things normally taken for granted, such as what is meant by "terminates." An Occam program can consist of many concurrent processes, and they can all terminate at different times; indeed, some may not terminate at all.

In Occam, there are only three primitive actions that a process can perform—namely, *assignment*, *input*, and *output*. Assignment is the same as it is in BASIC, C, or Pascal: It changes the value of a variable:

```
fred := 2 + x
```

Input and output involve passing a value to or from a *channel*. Channels are program entities that behave in some ways like variables; for example, they have a name and a type and must be declared before use (Occam II is a strongly typed language). A channel connects exactly two processes in only one direction; a bidirectional connection requires two channels. If a channel, chan1, connects two processes, proc1 and proc2, that are running in parallel, then proc1 may contain an output statement like this:

```
chan1 ! fred + 3
```

This means "output the value of variable fred + 3 on the channel chan1." The process proc2 may contain an input statement like this:

```
chan1 ? tom
```

which means "input from channel chan1 to the variable tom."

At first, it may help to think of input and output over channels as a way of assigning a value to a variable in another process. The net effect of the two statements above is rather like tom := fred + 3, except that tom exists inside a different process from fred. Shared global variables are forbidden in Occam. If a variable is assigned in process A, Occam will not allow you to use that variable in any other process running in parallel with A. (Compiler checks enforce this prohibition.) The only legal way to transfer a value from one parallel process to another is via a channel. You use variables only to store values, not transfer them. The rationale for this should become clear after some reflection. Logically it is the same problem as that of several users on a LAN accessing the same file—without record locking, chaos results. Occam uses the channel communication process instead of variable locking.

Both input and output processes are "patient"—that is, each will wait until the other is ready. So it is immaterial whether proc1 reaches its output statement before or after proc2 reaches its input statement; whichever arrives first waits for the other. A parallel Occam process runs completely asynchronously (i.e., at its own speed) until it must communicate with another process, at which point the two processes are forced into step while they exchange data, after which they go their separate ways again. Basically, this is the same idea as the "rendezvous" in Ada, but in Occam it is implicit and totally transparent to the programmer.

Because channels and processes are so fundamental to Occam, it's often useful to draw process diagrams that describe a

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program's structure rather than flowcharts. Figure 1 shows how you might diagram the simple situation described above.

Occam Programs

Occam programs are built up from the three primitive processes just described (i.e., assignment, input, and output) by combining them into more complex processes. Or, looking at it the other way around, Occam lets you hierarchically decompose a problem into a collection of concurrent processes communicating via channels.

The syntax of Occam looks fairly conventional to anyone who is used to Algol-derived languages such as Pascal. Only two things immediately stand out as being unusual. First, Occam uses indentation not just for increased readability, as in C and Pascal, but also as the sole delimiter of subprocesses; there is no equivalent of BEGIN...END or {..}. Second, because Occam permits parallel execution, sequential execution cannot be taken for granted as it is in ordinary languages. In Pascal or BASIC, if you write statements one after the other, you expect them to be executed one after the other. In Occam, if you want a sequence, you have to ask explicitly for a sequence. Suppose you have three processes called A, B, and C. Then, in the Occam construct

```
SEQ
  A
  B
  C
```

indenting A, B, and C by two spaces under the keyword SEQ, defines a compound process consisting of the sequence A followed by B followed by C. This process terminates when C terminates, much as in BASIC or Pascal. However, if you say

```
PAR
  A
  B
  C
```

you have specified a new process consisting of A, B, and C running *at the same time*. This process terminates when the slowest of A, B, and C terminates. You neither know nor care which process that may be. The simple communication example above looks like this when fully declared in Occam:

```
CHAN OF INT chan1:
INT fred, tom, jane:
PAR
  SEQ
    fred := 3
    chan1 ! fred + 2
  SEQ
    chan1 ? tom
    jane := tom * 20
```

The channel chan1 is declared to be able to carry integer values only (i.e., of type INT), and INT is said to be its protocol. This program results in fred=3, tom=5, and jane=100. Had you tried to use fred in the second SEQ as well, the compiler would have reported an illegal shared variable in a PAR. You could instead have declared the variables as local to their SEQs, in which case the problem can't even arise:

```
CHAN OF INT chan1:
PAR
  INT fred:
  SEQ
    fred := 3
    chan1 ! fred + 2
  INT tom, jane:
  SEQ
    chan1 ? tom
    jane := tom * 20
```

As a rule in Occam, it's best to keep all data local unless there's a pressing reason not to. You can name processes and give them parameters just as in C or Pascal, so you can go on to say

```
CHAN OF INT chan1:
PROC proc1(INT x)
  INT fred:
  SEQ
    fred := 3
    chan1 ! fred + x
:
PROC proc2(INT y)
  INT tom, jane:
  SEQ
    chan1 ? tom
    jane := tom * y
:
PAR              -- main process starts here
  proc1(3)
  proc2(20)
```

Other Control Processes

In Occam, you have several other ways of combining primitive processes besides PAR and SEQ—for example, IF, WHILE, CASE, and ALT. The conditional process IF executes the first process whose test is true. The selection process CASE operates similarly but uses literal selector values instead of tests. WHILE provides a conditional loop like that of C and Pascal. The most interesting control process of all is ALT, the alternative process, which has no equivalent in sequential languages. Consider the following program fragment:

continued

```
ALT
  right ? x
    out ! x
  left ? x
    out ! x
```

The ALT process watches channels left and right and executes the subprocess associated with whichever one produces a result first; it's like a first-past-the-post race between the channels. Here, the subprocess is the same for both, merely outputting the received value on the single channel out. If you iterate the ALT process, it has the effect of merging or time-multiplexing two input streams into one output stream. The process below merges two streams of complex numbers until you stop it by sending the Boolean value FALSE on channel shutoff:

```
PROTOCOL COMPLEX IS REAL64;REAL64:
PROC merge(CHAN OF COMPLEX right,
           left, out;
           CHAN OF BOOL shutoff)
  REAL64 x.real, x.imag:
  BOOL running:
  SEQ
    running := TRUE
    WHILE running
      ALT
        shutoff ? running
           SKIP
        right ? x.real; x.imag
          out ! x.real; x.imag
        left ?  x.real; x.imag
          out ! x.real; x.imag
:
```

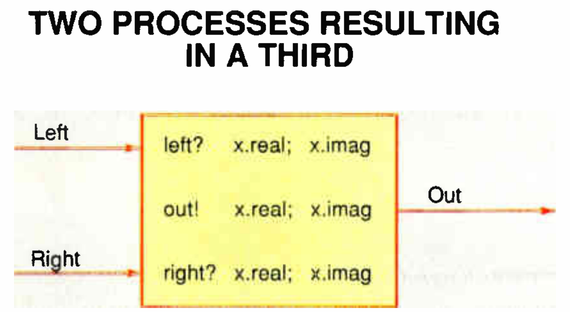

Figure 2: *A process diagram of two input streams multiplexed into a single output stream. The Boolean value* FALSE *on channel* shutoff *will terminate the program.*

Table 1: *Occam II supports a full range of type conversion and IEEE rounding and the following data types:*

BYTE
INT (size defined by executing hardware)
INT16
INT32
INT64
REAL32
REAL64
BOOL

Figure 2 shows the process diagram for this example.

This process illustrates several further points about Occam: It supports a 64-bit ANSI/IEEE floating-point data type REAL64 (other supported data types are shown in table 1); channels can have structured rather than simple protocols; more than one variable can be changed by a single input or output; although Occam has structured channel protocols, it does not have corresponding structured variables or records, so a sequence of simple variables has to suffice.

Arrays

Occam supports arrays of both processes and channels in addition to plain data arrays. An array of SEQ processes is just a way of describing a counted loop similar to Pascal's for loop. To illustrate, here's a process that prints strings to a screen:

```
PLACE screen AT 8:

PROC writestr(CHAN OF BYTE stream; VAL []BYTE
      string)
  SEQ i := 0 FOR SIZE string
    stream ! string[i] : SEQ
  writestr(screen, "Hello world!")
```

SIZE is a built-in Occam function that returns the size of an array. Note that Occam does not support separate character or string types but treats them as bytes and arrays of bytes. The process uses PLACE to make *screen* a physical hardware channel (see below).

An array of PAR processes is a central construct in the Occam style of programming. It describes a pipeline of processes in which you can pass data from one process to another and subject it to the same operation at each stage. The simplest example of the use of such a "replicated" PAR is to implement a queue or buffer structure such as this terminal type-ahead buffer:

```
[21]CHAN OF BYTE buffer:
PROC keyboard.input()
  WHILE TRUE
    BYTE char:
    SEQ
      keyboard ? char      -- get a character from
                              the keyboard
      buffer[0] ! char     -- put it into the
                              pipeline
:
PROC terminal.output()
  WHILE TRUE
    BYTE char:
    SEQ
      buffer[20] ? char    -- get a character from
                              the pipeline
      screen ! char        -- display it
:
PROC type.ahead()
  PAR i := 0 FOR 20        -- 20 parallel
                              processes
    WHILE TRUE             -- all like this...
      BYTE char:
      SEQ
        buffer[i] ? char      -- pass the
                                 character
                                 on to...
        buffer[i+1] ! char    -- ...the next stage
:
```

```
PAR
  keyboard.input()
  type.ahead()
  terminal.output()
```

The main process, type.ahead, is a replicated PAR that simply passes characters along the line of channels called buffer from the keyboard input process to the screen output process. All three processes run in parallel. The buffer is self-regulating thanks to the nature of Occam channel communication; it can't overflow or underflow but waits patiently in either case.

You can use an array of parallel processes for parallel sorting, vector arithmetic, or graphics ray tracing by performing computations on the data rather than just passing it along. Of course, to reap any performance benefit, you must assign a physical processor to each component of the replicated PAR, although you can develop and test the program by time slicing on a single processor.

Real-Time and Hardware Matters

Once you have debugged an Occam program to the point where the logic is correct, you can turn to matters of configuration and performance. Occam provides the means to assign processes to physical transputers and channels to physical transputer links. It also supports I/O ports (so you can write device drivers for conventional peripheral chips) and the absolute location of program objects in memory (for memory-mapped devices).

You use the keywords PLACE and PLACED to associate channels and processes with physical devices. The body of a pipelined ray-tracing program may contain declarations of this kind when configured to run on several transputers:

```
VAL number.transputers IS 50 :
PROTOCOL PIXELPACK IS INT::[]INT :
[number.transputers]CHAN OF PIXELPACK forward,
        return :
........

PLACED PAR i := 0 FOR number.transputers
  PROCESSOR i T8
    PLACE forward[i]   AT link0in :
    PLACE forward[i+1] AT link1out:
    PLACE return[i]    AT link1in :
    PLACE return[i]    AT link0out:
    calculate(forward[i], forward[i+1],
        return[i], return[i+1])
```

The user-defined process calculate performs ray-tracing computations on batches of "raw" pixels that are sent outward on the array of channels named forward; the processed results are sent back along the return channels. The protocol PIXELPACK is a 16-bit count followed by an array containing that number of 16-bit pixels. The PLACED PAR assigns an array of 50 parallel calculating processes to a pipeline of 50 T800 transputers (PROCESSOR i T8), and the PLACE statements assign the Occam channel names (forward[i], and so on) to real transputer links (link1in, and so on). Figure 3 diagrams this process.

I have simplified this example drastically—a real ray-tracing program is much more complex. You can also use PLACE to put variables or arrays at absolute memory addresses, just like absolute variables in Turbo Pascal.

Performance in Occam programs is not just a matter of the number of processors employed; process priority can become an issue, too. In general, Occam discourages the use of priority, preferring to allow channels to self-synchronize. Although you can develop most programs without prioritization, it may become unavoidable in real-time applications. The keyword PRI can be applied to both PAR and ALT processes to establish one component's priority over all the others. Thus, in

```
PRI PAR
  A
  B
  C
```

process A has priority, and processes B and C can proceed only when A is waiting on an input or output. A good example of the use of a PRI ALT is to mix a stream of serial data from a UART chip with data from an Occam channel; the UART is an "impatient" external device that can lose data if kept waiting:

```
TIMER clock:
... more declarations
SEQ
  clock ? time              -- get start time
  WHILE active
    SEQ
      time := time PLUS interval
      PRI ALT
        clock ? AFTER time -- is it time to check
                              the UART yet?
          SEQ
            get.UART(char)
            to.buffer ! char
        source ? char       -- otherwise get from
                              channel
          to.buffer ! char
```

The user-defined process get.UART checks the UART's status register and gets a character if one is ready; clock demonstrates another kind of Occam object, a timer that acts like a channel that delivers the current time. The operators PLUS and AFTER are used to do modulo arithmetic on time values. The value of interval would be set just short of the shortest possible time in which a new serial character can arrive (that time, in seconds, is about 10 divided by the baud rate). Thus, processor time is not wasted in a "busy wait" when no UART data is due.

Limitations of Occam

There has been much misunderstanding about how high-level the Occam language is. Occam is very intimately linked to the transputer instruction set, to the point where many Occam constructs compile to single instructions. In fact, INMOS intended Occam to be the assembly language of the transputer, the lowest level at which it can be programmed. Some assemblers are now available for the transputer, but parallel assembly pro-

continued

CHAINING PROCESSES

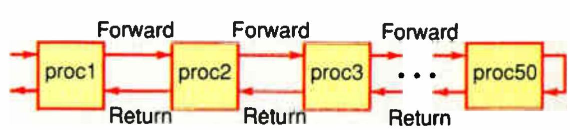

Figure 3: *A simplified diagram of ray tracing using 50 parallel T80 transputers.*

gramming is strictly for heroes. Viewed as an assembly language and compared to 8086 or 68000 assembly languages, Occam is very high-level indeed. But compared to Pascal or C, it is rather low-level, lacking, for example, record types and structures. Moreover, it is a static language (like FORTRAN), in which all the resources a program needs must be known and allocated at compile time. This means that it does not support a stack or a heap and so does not permit recursive procedures.

This was a deliberate, if radical, design decision by INMOS. The transputer was not designed to compete head-on with the Intel and Motorola chips as a general-purpose single CPU, but rather to be a programmable component for very high-performance parallel applications, often of the embedded type. Typical transputer applications have been distributed control systems, laser printer engines, graphics processors, image-processing arrays, and signal processors. For such applications, Occam needs to be efficient and secure. It must also be capable of running without an operating system, on the raw hardware, and, perhaps, using only the on-chip memory.

It would have been possible to make Occam a stack-based, block-structured language like C, but then every parallel process would have to have its own stack, which requires a dynamic memory-allocation scheme (like that in Unix) for which the transputer provides no hardware support. Such schemes mean large memory overheads and degraded context switching; a raw Occam process can be switched in about 1 microsecond compared to about 100 microseconds for Unix tasks.

Another point is that the static nature of Occam allows compiler checks to catch most logic errors (apart from deadlock) at compile time while reducing the number of possible run-time errors and making them cheaper to detect—important benefits for high-security applications. It seems likely that transputer users will be split into two camps for some time. Some will want a fuller operating system, such as the Helios system (see "A Personal Transputer," June 1988 BYTE). They'll also want a C compiler but will be prepared to accept reduced performance. Others will need the minimalism of Occam. Eventually, the camps could be reunited if INMOS is ready to produce a dynamic version of Occam when the next generation of transputers provides the needed hardware memory management.

A "Novel Calculus"

These few examples, I hope, have conveyed some of the feel of Occam programming. Designing Occam programs is certainly different from designing sequential programs; often it is more like designing electronic circuits where you "wire" together a number of active components, the wire being channels and the components being parallel processes.

While Occam is a safe, elegant, and efficient way to program transputer networks, it is also something more; it's a novel calculus or way of thinking about concurrent systems. The clean syntax of Pascal has made it the textbook language in which to express sequential algorithms. I believe that Occam can fulfill the same role for parallel algorithms. Occam has well-defined algebraic semantics that allows accuracy-preserving transformations to be performed on program text. INMOS design engineers have used a specification written in high-level Occam, via a transformation system, to verify the accuracy of the microcode that implements the FPU of the T800 transputer. In future designs for hardware, this microcode may be "compiled into silicon" from the Occam descriptions. ■

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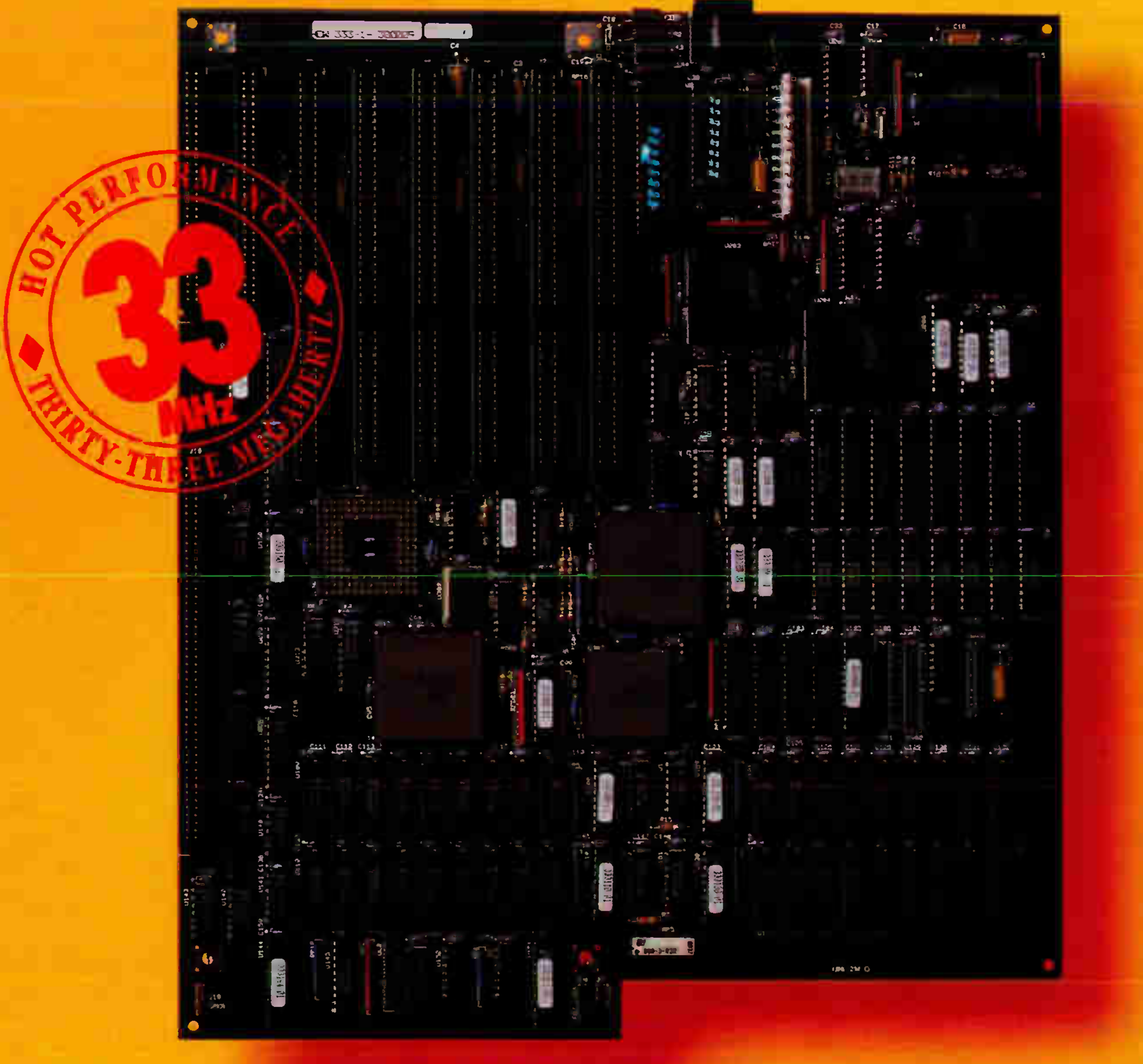

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- 1P, 1S Port

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40MB	1500	1950	2020
80MB	1765	2215	2285

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Sony 1302P	Call

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NEC P2200	$330
NEC P5200	525
NEC P5300	695
Okidata 320P	375
Okidata 321P	520
Okidata 390	520
Okidata 391	705
Okidata 393	1105
Okidata 393C	1185
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Toshiba 311	380
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Paradise EGA-480	210
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Paradise VGA-Plus-16	320
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Archive VP601	675
Mountain 4340	400

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Intel 80287-10	260
Intel 80387-16	415
Intel 80387-20	470
Intel 80387-25	590
Intel 80387SX	375
Intel 80c287	315

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dBASEIV	450
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Lotus Symphony	415
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Microsoft Windows 386	130
Microsoft Excell	285
Microsoft Word	215
Microsoft Works	105
Paradox 3.0	415
PFS First Publisher	70
Ventura Publisher	485
Word Perfect 5.0	220
Symantac Q&A 3.0	215
Symantac Q&A 386	Call

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Logitech Bus Mouse	Call
Microsoft Mice	Call

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US Robotics 2400	Call
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Okitel 2400B int	200
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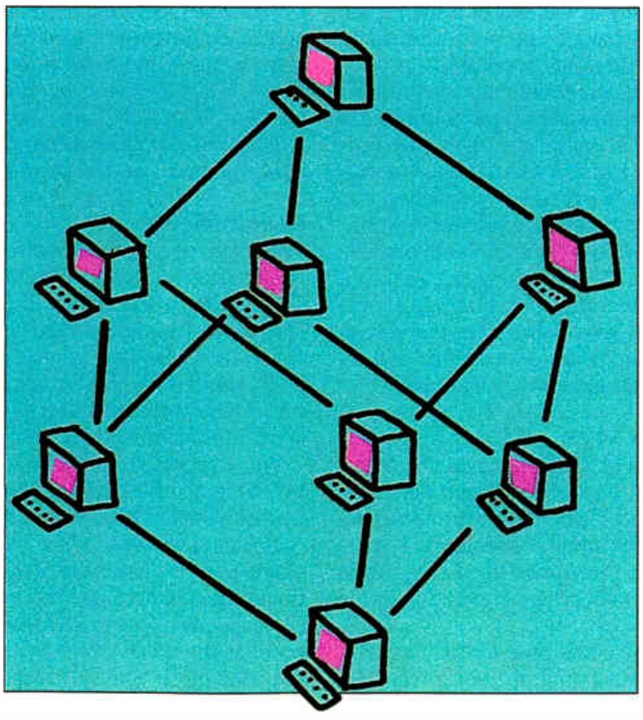
HANDS-ON PARALLEL PROCESSING

An inexpensive way to set up your own hypercube system using Macs and AppleTalk

Geoffrey C. Fox, Alex W. Ho, Paul Messina, and Terry Cole

The promise of parallel computing is performance: unprecedented performance in large configurations and a better price/performance even in small systems. However, programming parallel systems to perform concurrent computations requires new techniques best learned through hands-on experience on real parallel computers.

Many wishing to learn or teach parallel programming cannot afford to buy a commercial parallel computer. We'll describe how to create a parallel computer (of a type known as a hypercube) using an ensemble of Apple Macintosh computers and AppleTalk. For more information about parallel computers in general, refer to the text box "The Drive for Parallel Systems" on page 288.



The Hypercube

A p-dimensional hypercube computer, also called a p-cube, has 2^p processors that can be thought of as being located at the vertices of a p-dimensional cube (see figure 1). The physical connections among the node processors lie along the edges of the hypercube. Each node processor of a p-cube is connected to p other processors. In the case of a three-dimensional cube, the total number of node processors is eight and each node is connected to three other nodes. Higher-dimensional cubes can be formed recursively from lower-dimensional cubes. The maximum number of stages a message might have to traverse in a p-dimensional hypercube is p, as opposed to $2^{(p-1)}$ steps for a physical ring connection.

The hypercube architecture has the added advantage of being able to map conveniently to a wide range of simple topologies, such as a ring, a grid, a pyramid, or a binary tree, while requiring a modest number of physical connections at each node. In a 1024-node system, for example, 10 communication channels are needed. Currently available hypercube systems include the Caltech/JPL Mark Series computers and the commercial systems of Intel Personal Scientific Computer (iPSC), NCUBE, and Ametek.

In most of the current hypercube systems, the node processors are not connected to any I/O peripheral devices. To provide them with I/O capability, a computer called a control processor (CP) or cube manager is connected to one or more node processors (see figure 1).

A CP is a conventional computer with ordinary I/O devices. It is the only path from the outside world to the hypercube, and vice versa. Programmers can interact with the hypercube only via the CP. To run an application program on a hypercube, the program must be downloaded from the CP. When data has

continued

ILLUSTRATION: CATHARINE BENNETT © 1989

The Drive for Parallel Systems

Scientists, researchers, and engineers all over the world are clamoring for computer systems that will enable them to approach and solve large-scale problems realistically. For instance, to carry out a meaningful numerical study of quantum chromodynamics (a theory of fundamental particles) would require repeated recalculation of about 100 million values representing various field strengths in the four-dimensional space-time region near a proton. In the field of computational fluid dynamics, to adequately model the fine structures of three-dimensional high-Reynolds-number (turbulent) flow would consume an enormous number of computer cycles.

The demand for higher-performance computers is rising. But the performance of conventional supercomputers is approaching its fundamental physical limit, which is imposed by the speed of light (about 1 foot per nanosecond), the fastest possible speed a signal would be able to travel from one part of the computer to another (see reference 7 in the main text). Even if the physical size of a single-processor computer could be made very small and its components could send signals at the speed of light, such a computer still could not achieve more than a few billion instructions per second, which is not enough for applications that are derived from various contexts such as physics, fluid dynamics, or real-time image and natural-language processing, just to name a few.

The advancement of semiconductor and VLSI technology will make individual processing units substantially cheaper but cannot improve their performance to a comparable extent. To obtain an appreciable increase in the throughput rate of a computer system, the system must be able to overcome the sequential bottleneck of the Von Neumann architecture.

To address this issue, new computer architectures are required that use many processors to work on the same problem at the same time. In other words, what we need is concurrent or parallel processing.

Most computers have only one processing unit, the CPU, that performs all the computational work. Computer programs, written in languages such as C or FORTRAN, are compiled (i.e., translated) into a sequence of machine instructions. These instructions must be executed sequentially by the computer. However, many applications are inherently parallel, as in most real-world phenomena. If we can capitalize on the parallelism of these applications by using concurrent processing to overcome the sequential bottleneck of the conventional design, we can achieve faster execution and increase throughput.

In addition to providing a path to unprecedented speed, another strong motivation for designing and using parallel computers is the hope for better price/performance than sequential systems offer. Microprocessors of moderate speed are produced by the millions for personal computers and other applications. Their internal speeds and feature sizes do not require the most expensive fabrication techniques. While one microprocessor is not terribly powerful, dozens or hundreds of microprocessors organized as one computing system can perform sizable computations.

Combining 20 5-MIPS microcomputers could yield an equivalent of 100 MIPS, a speed that few sequential computers can achieve. The price of the components in the microcomputer-based system is much less than that of a sequential computer of comparable speed. Of course, programming the parallel system efficiently may be more difficult than programming the sequential one, particularly for those who have grown up in a serial programming environment.

to be written onto disk or tape, say at the end of a hypercube application, the node processors have to be programmed to send their data to the CP, where file I/O is possible.

Programming a hypercube concurrent computer isn't difficult, but it's also not as straightforward as programming a sequential machine, especially for those of us who have programmed sequentially for years. Hands-on experience in programming a hypercube is extremely valuable for learning and understanding how concurrent computers and programs work.

It may be extravagant to buy a small commercial hypercube computer just to learn about parallel processing or to teach a class in advanced computer architectures. One alternative is to assemble your own hypercube, the Mac-Cube, using the Macintosh family. This is especially desirable for academic and research environments in which Macs are already abundant.

The Mac-Cube

We have designed and fabricated a Mac-based hypercube with a companion operating system and named the group the Mac-Cube (see reference 1). It uses LocalTalk hardware and AppleTalk software as the medium for the nodal connections. Hypercube connectivity is emulated on the AppleTalk LAN, while the hypercube communications protocol is integrated with the AppleTalk software.

Available for use with the Mac-Cube is Mac-CrOS, an MPW C and assembly language implementation of the Caltech/JPL Crystalline Operating System, also known as CrOS III (see reference 2). Software based on Mac-CrOS is portable across all commercial hypercubes running CrOS III. [Editor's note: *The Mac-CrOS software is available from several sources. See the text box "Parallel-Processing Resources" on page 293 for details on obtaining resources from Caltech. Also see page 5 for information about files available on BIX.*]

Requirements

The required hardware and software for setting up a Mac-Cube is separated into two parts: the CP and the node processors. A CP requires a Macintosh Plus, SE, or II; a 10-megabyte hard disk drive (minimum configuration); System 4.1 and Finder 5.5 (Mac-Cube has been tested with these versions, though later versions should be compatible); MPW 2.0; and the C^{3P} Mac-Cube software library (which contains Mac-CrOS and a configuration program).

Node processors require a Mac Plus, SE, or II; one 800K-byte floppy disk drive; System 4.1 and Finder 5.5; and a start-up disk with C^{3P} Mac-Cube configuration software.

A functional Mac-Cube hypercube consists of $2^p + 1$ Macs, where p is the dimension of the hypercube. For the implementation discussed here, the p dimension is between 0 and 4, which corresponds to one to 16 Macs. Of the total $2^p + 1$ machines, 2^p serve as the nodes of the hypercube and can be any member of the Macintosh family except the Mac 128K. The additional

Parallel Processors

The performance of parallel processors is related to the underlying architecture of the system and the mode of processor coordination. There are two major categories of parallel architecture. In the SIMD (single instruction and multiple data stream) system, the processors perform the same instruction at each cycle, but each operates on different data. In an MIMD (multiple instruction and multiple data stream) system, the processors can run independently. Each processor can execute different portions of the same program or completely different programs.

An important aspect of multiple-processor architectures is how the processors are associated with memory. In *shared-memory* systems, all processors access the common physical memory by direct connections, by a network of connections, or by a memory bus. Shared-memory systems enable each processor to operate on data that is also accessible to other processors. Because all processors can modify stored data, care must be taken to avoid attempts by processors to gain access to data before the appropriate value has been stored.

One limitation of shared-memory architecture is that it appears to be expensive and difficult to produce massively parallel systems—that is, systems with hundreds or thousands of processors. Examples of shared-memory parallel computers are Cray's Cray-2, ETA's ETA 10, Bolt Beranek and Newman's Butterfly, ELXSI's System 6400, and IBM's RP3, among others.

In contrast to the shared-memory model, there are the *distributed-memory* or *local-memory* systems. This form of processor/memory relationship exists when some amount of memory (local memory) is attached to each processor, and connections are established among the processor-memory pairs (also designated as node processors, or simply nodes). In a distributed-memory system, each processor has direct access to only its own local memory.

If a processor has to access or modify the value of a piece of data that does not exist in its local memory, message-passing via communication channels is the mechanism required to achieve the task. The communication channels are the actual physical linkages of the individual processors and can be arranged in an arbitrary network topology. A disadvantage of network communication is an increase in latency of memory access, because a request for information by a processor may have to traverse several stages of the connection network to get to the particular memory unit that has the data.

Some Network Topologies

A simple scheme for connecting distributed processors is the ring topology in which each node processor is connected to two other processors. Another simple scheme is a rectangular grid. In this configuration, each processor is connected to the four other processors that are its nearest neighbors. A significant drawback of simple topologies such as these is that the number of processors involved in coordinating the sending of a message from one node processor to another could be very large. In the case of a ring, as many as half the total processors could be involved. The resources of a node processor will be wasted if it has nothing to do while waiting for a message to arrive.

In designing high-performance distributed-memory parallel processors, several criteria must be satisfied by the connection network: fast communication among nodes, simple connectivity for each node, and a connection topology that matches the natural geometry of applications. The hypercube topology discussed in this article is used by several vendors of commercial distributed-memory systems to meet these criteria.

Macintosh is used as the CP. Usually, the CP is used for developing applications. If this is the case, the CP must be capable of running the MPW. Mac-CrOS applications can be developed using C or Pascal inside the MPW environment. The minimum recommended configuration for the CP doing development work is a Mac Plus with a 20-megabyte hard disk drive.

All nodes of a Mac-Cube must be in the same AppleTalk zone. Any number of other Macs, as well as AppleTalk gateways, can also be in the same local zone without interfering with Mac-CrOS. Multiple Mac-Cubes can coexist in the same AppleTalk zone, as shown in figure 2. A 2-cube, five-Mac system (four nodes and a CP) and a 3-cube, nine-Mac system (eight nodes and a CP) are illustrated.

Mac-Cube as an Instructional Tool

Mac-Cube has several advantages over commercial hypercubes as an instructional or experimental tool for parallel processing. One major advantage is its low setup cost. Most university computer laboratories or research laboratories have numerous Macs in close proximity; very likely, they are already connected using the AppleTalk LAN. In this case, no additional hardware is needed to assemble a Mac-Cube. Using some of the Macs on the local AppleTalk network does not disturb other computers on the same network. In other words, while some students are using several Macs on an AppleTalk network in the normal sequential mode, others can configure a few of the remaining Macs into a single or multiple Mac-Cube(s).

A second advantage is its ease of use. Nodes of commercial hypercubes are not equipped with I/O devices such as display monitors, yet each node of a Mac-Cube (i.e., a Macintosh computer) always has a graphics display monitor and input devices such as a mouse and a keyboard. The availability of a display device at each node enables users to see and to demonstrate how parallel algorithms function. Graphics display capability at the nodes has high educational value, as applications can display information in a spatially intuitive and descriptive manner. Moreover, Macintosh graphics are superior to those typically found on mainframe or minicomputer terminals.

Viewing the actions of an application at each node actually facilitates debugging, because errors can be pinpointed to specific nodes. In addition, taking advantage of the availability of I/O devices at each node makes it possible to implement multiuser applications, such as distributed expert systems and databases.

A Closer Look at CrOS

CrOS is a loosely synchronous message-passing system for hypercube-connected or hypercube-emulated environments. It is a channel-based, point-to-point *polled* communication system that enables directly connected nodes of a hypercube to communicate with each other. CrOS is efficient and well suited for

continued

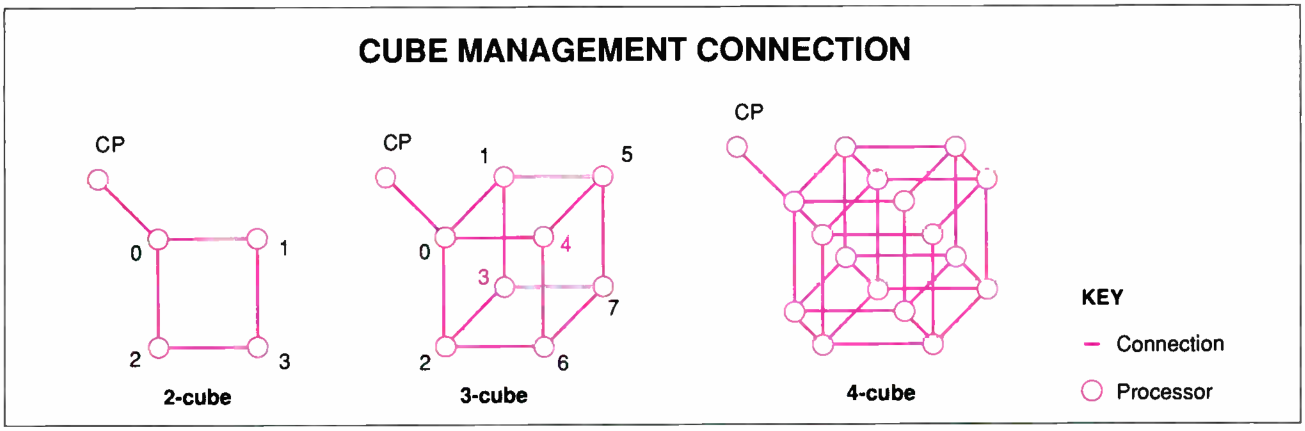


Figure 1: *Hypercubes of dimensions 2, 3, and 4. Each cube has* 2^p *processing nodes and a single control processor, and each node is connected to* p *other processors. Thus, a 2-cube has four processing nodes and one control processor, and each processing node is connected to two other nodes.*

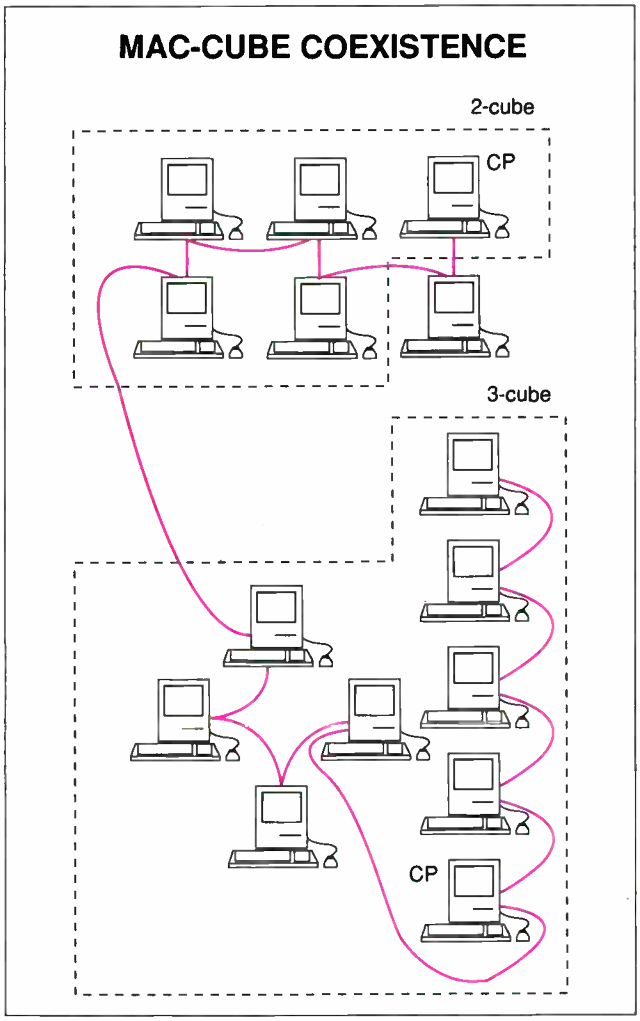


Figure 2: *Sample Mac-Cube hypercubes on an AppleTalk network. Note that there are 2-cube and 3-cube systems on the same network and that the lone (shaded) user is undisturbed except for the network loading added by the Mac-Cubes. Also, the Macs that make up each cube do not need to be contiguous.*

problems with regular or homogeneous domains—hence the name "Crystalline."

When polled communication is used, the application program contains explicit read and write command pairs. For example, let's assume that node 1 needs to write to node 3. When node 1 is ready to write to node 3, it must issue a "write to node 3" command. But before the write can proceed, node 3 must issue a "read from node 1" command. If node 3 is operating on other instructions when node 1 sends its request to write, node 1 will halt until node 3 finishes the instructions it already has. Only when node 3 replies with a "read from node 1" command can node 1 actually perform the write.

The reverse is also true. Should node 3 want to read from node 1, it will issue a "read from node 1" command, but it cannot continue until it receives a reply. Because the nodes cannot proceed until the write and read command pairs are exchanged, they move in lockstep through their programs, with each read and write command resynchronizing the processors.

Listings 1a and 1b show examples of the command pairing previously described. Listing 1a runs on the nodes and implements `dumpelt()`, which is a command that dumps data from the nodes to the CP. Listing 1b runs on the CP and implements `mdumpcp()`, which also requests a data dump from the nodes to the CP.

Examples of rigorous scientific applications using CrOS on hypercubes can be found in fields such as neural-circuit simulation, protein dynamics, chemical reactions, chaos, computational fluid dynamics, earthquake engineering, convolution decoding, ray tracing in computer graphics, seismic waves, geodynamics, tomography, computational astrophysics, lattice gauge theory in high-energy physics, condensed matter, and granular physics (see reference 3). These algorithms are described in an excellent set of application papers (see reference 4), which contains 180 papers, including over 30 Caltech CrOS applications. Reference 5 contains public domain software with source code for the algorithms described in reference 3.

Developing CrOS applications for Mac-Cube is similar to developing applications for other commercial hypercubes. A CrOS application always contains a CP program and a node program pair. Generally, the CP program is used to download the node program—which is developed and compiled on the control processor—to the node processors. The CP program also distributes initial data to the appropriate node processors. Major computation, which can mostly be parallelized, takes place on the node program running on the node processors. The CP will then receive computational results from the node processors and display them or save them for later analysis.

Executing CrOS Applications

Before starting an application, you must decide which computers will be the node computers and which computer will be the CP. It doesn't matter in what order the node and CP computers are connected by AppleTalk. The only requirement is that they are all on the same AppleTalk network. Not all computers on the network have to be assigned to one Mac-Cube or multiple Mac-Cubes; the unassigned computers can operate normally while some cubes are running.

Before running a CrOS application, you must "collect a hypercube" by running boot and bootelt on the CP and the nodes, respectively. These programs tell the CP computer how many node computers are available on the network and their addresses. After this procedure collects enough Macs and configures them as a Mac-Cube of a known dimension, the parallel application can be executed inside or outside the MPW shell.

The configured Mac-Cube remains intact after the execution of a program, so you can execute other applications without reconfiguring or rebooting for each application. If you want to change the dimension of a configured Mac-Cube (i.e., add or delete some nodes or change the CP), the Cube must first be "uncollected" by running the unboot program. To "re-collect" a new Mac-Cube configuration, the same procedures as described above apply. A sample Mac-Cube configuration session is displayed in figure 3.

Debugging CrOS Applications

Debugging concurrent applications on most commercial hypercubes can be difficult. Fortunately, having a graphics display monitor on each node makes debugging on Mac-Cube easier. Moreover, by virtue of the physical ring structure of LocalTalk, all the communications on a Mac-Cube can be easily monitored by watching the one LocalTalk line that physically connects all the nodes.

Two tools have proved useful in debugging CrOS applications: a Macintosh assembly-level debugger and AppleTalk Peek (from Apple Computer Network Systems Development). As distributed, Mac-CrOS code has been compiled with the source names option so that the name of the routine currently being executed is available from the debugger. It's easy to get some idea of what happens in a program by using a debugger. Breakpoints also can be inserted at key places in the programs.

AppleTalk Peek is a program that monitors packet activity at the lowest level. Each CrOS packet corresponds to at least four of the low-level AppleTalk packets. Additionally, each CrOS communication routine will use one or more of the CrOS packets. With a knowledge of the packet structure used by low-level CrOS routines (as documented in the CrOS source code), as well as a knowledge of which actual CrOS packets are sent, you can often determine the state of communications fairly easily.

AppleTalk Communications

Communication in Mac-Cube is implemented using LocalTalk, a baseband, ring-topology network that is inexpensive and widely used. Unfortunately, because only one message travels on the bus at a time, LocalTalk is ill-suited to efficiently emulate the hypercube topology that enables messages to travel in concurrent pathways. As a consequence, the Mac-Cube is a less efficient implementation than the PC-Cube (see reference 6), which is another "build-it-yourself" educational hypercube

continued

Listing 1: (a) *This program runs on the Mac-Cube nodes to dump specific memory locations in each node to the control processor (CP).* **(b)** *This memory-dump code runs on the CP and is a complement to listing 1a. Both node and CP programs must run and be acknowledged by each other for the requested memory dump to occur.*

(a)

```
/*
 * crosnode.c
 *
 * example CrOS NODE program : all the nodes do a
 * dumpelt( ) and check for errors. dumpelt( ) is a CrOS
 * function that dumps data from nodes to the CP. A call to
 * dumpelt( ) must be complemented by a call to mdumpcp( ) or
 * fdumpcp( ) in the CP.
 *
 */

#include "croselt.h"

main( )
{
     struct Cubenv env;
     int OKflag, isize;

     cparam(&env);  /* gets run-time parameters */
     isize = sizeof(int);
     OKflag  = dumpelt(&env.procnum, isize); /* dumps
                                 processor ID to CP */
     if (OKflag >= 0)
         printf("Communication OK.\n");
     else
         printf("Communication error.\n");
}
```

(b)

```
/*
 * croscp.c
 *
 * Example CrOS CP program: The CP does mdumpcp( ) and checks
 * for errors. mdumpcp( ) is a CrOS function that dumps
 * data from nodes to CP's memory. A call to mdumpcp( ) on
 * the CP must be complemented with a call to dumpelt( ) on
 * all the nodes.
 *
 */

#include "croscp.h"

main( )
{
     struct Cubenv env;  /* contains run-time parameters */
     int OKflag, i, isize;
     int data[32], buf[32];

     printf("Downloading to Cube...\n");
     cubeld(2, "crosnode");  /* downloads node program to a
                                 2-cube */
    (Press RETURN for more or ESC to cancel)
     printf("Downloading done.\n");
     cparam(&env);  /* fills structure env */
     isize = sizeof(int);
     OKflag = mdumpcp(buffer, isize, buf);
     if (env.nproc != buf[0]) OKflag = -1;
     for (i = 0; i < env.nproc; ++i)
         if ((buf[i+1] != sizeof(int)) || (data[i] != i))
             OKflag = -1;
     if (OKflag >= 0)
         printf("Communication OK.\n");
     else        printf("Communication error.\n");
}
```

Figure 3: *Procedures to configure a Mac-Cube of dimension 2 (four Macs, one CP) and execute a program named* `TestProgram`. *Then the nodes are released and used to configure a 1-cube (two Macs, one CP), execute* `TestProgram` *again on the 1-cube, and release all the nodes completely.*

```
File  Edit  Find  Mark  Window  Directory  Build
Server:MPW:Worksheet

boot -d 2                          # Gather four nodes for the cube.
This is Node 119 Net 14337         # The node numbers are the Appletalk
node is 39.                        # ID numbers.  They are only for diagnostic
node is 66.                        # purposes.
node is 77.
node is 68.

TestProgram                        # A test program that gets a message from
Hello from 0.                      # each node.
Hello from 1.
Hello from 2.
Hello from 3.

boot -f                            # Free the nodes used in the cube.
                                   # They can still be used for another cube.

boot -d 1                          # Gather two of them for another cube.
This is node 119 Net 14337
node is 66.
node is 68.

TestProgram
Hello from 0.
Hello from 1.

boot -q                            # Release the nodes for good.
MPW Shell
```

system, based on IBM PCs or compatibles.

Communications under AppleTalk were designed with the International Standards Organization standard for network communications in mind. The highest level (called the transport level in the ISO model) of "guaranteed datagram delivery" is implemented through the AppleTalk Transaction Protocol. It would be easy to implement hypercube communications using ATP. However, ATP is designed to handle a more sophisticated networking environment than is needed for CrOS, and thus it would introduce an additional level of inefficiency into an already inefficient environment.

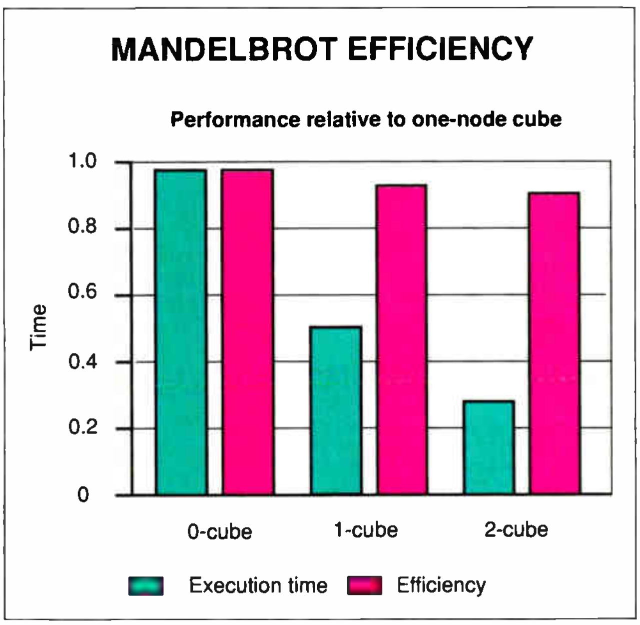


Figure 4: *Efficiency versus execution time of a 0-, 1-, and 2-cube Mac-Cube, which translates to one, two, and four Macs, respectively. Because the communication overhead also increases as nodes are added, the efficiency declines slightly. For example, adding three more processors to a single-processor node (for a total of four) reduces execution time to a little more than one-fourth of the single processor's time.*

In order to get higher communication efficiency, the ATP routines were bypassed for CrOS, and communication was implemented using the AppleTalk Link Access Protocol. At this level, next to the physical or hardware level, communication is streamlined, but packets are no longer "guaranteed" to reach their destinations. Because of this, the implementation of Mac-CrOS software is intelligent in its interactions with the hardware and the operating system to monitor packet activity. It is also more efficient.

Mac-CrOS is implemented in terms of the low-level, Mac-Cube-specific `cread()`, `cwrite()`, `vread()`, and `vwrite()`, in addition to the generic higher-level routines. The low-level Mac-CrOS routines consist of assembly language code that interacts in real time with the asynchronous AppleTalk drivers at a very low level. Global data structures are used to share information between this low-level code and the higher-level, synchronous C language codes that are used to implement the other Mac-Cube-specific CrOS routines.

Certain global data structures are initialized when the first Mac-CrOS routine in a program is called. However, basic information, such as the maximum hypercube dimension, the registered name of the CP, the AppleTalk addresses of all the nodes of the hypercube, and the address of the CP, cannot be gathered effectively at run time.

For this reason, a "boot-up" program is used to gather the node computers that will be used coherently and cooperatively as a hypercube. The boot-up program stores its data in the system heap as a system resource so that the hypercube will remain intact between program runs. This program is also used to release nodes from a Mac-Cube and to verify that all the nodes are still in place after a program has been run. The boot-up program enables multiple hypercubes per AppleTalk network. This program uses the higher-level ATP routines as well as the

Parallel-Processing Resources

In this article, we have described the Mac-Cube, an excellent low-cost system that emulates more sophisticated parallel computers. *Solving Problems on Concurrent Processors* (see reference 3) and its software supplement (see reference 5) provide an introduction to parallel processing and a large selection of tutorial software. Much of this is in the public domain and can be obtained from Caltech using c3plib, an electronic distribution system for software and documentation from C[3P] (Caltech Concurrent Computation Program), described below.

Mac-Cube-related software is available from c3plib and on BIX (see page 5 for further details). Another small tutorial system is based on the IBM PC-Cube (see reference 6), for which software can be obtained from c3plib. The PC-Cube is also commercially supported by Parasoft of Mission Viejo, California. Other elegant tutorial systems are built around add-on boards for Macs, Suns, and PCs. The most modern of these use transputers, each of which has a 10-MIPS performance. CrOS software for these add-on boards is discussed in reference 5 and can be obtained commercially from Parasoft at 27415 Trabuco Cir., Mission Viejo, CA 92692, (714) 380-8375.

Software Distribution: c3plib

The c3plib system is a file server at Caltech for the distribution of concurrent computation software, documentation, and reports from C[3P]. It's essentially a program that answers E-mail requests by responding with the appropriate material by E-mail. Requests should be addressed to "c3plib@caltech.edu" (for INTERNET users) or "c3plib@caltech.bitnet" (for BITNET users).

The file server understands several commands, and each command must be the first word on a line. The principal command is `send`. For example, the server will respond to a one-line `send help` message by sending a help file with detailed instructions about using the file server. A `send index` message will get the requester an index file that gives an overview of directory and file structure. If you don't have access to the network, requests for information should be sent to C[3P] Requests, Caltech Concurrent Computation Program, 206-49, Pasadena, CA 91125.

Name Binding Protocol to enable the nodes to find the CP.

Code Compatibility and Cube Efficiency Mac-CrOS has been tested on the Mac SE and the Mac II. Two CrOS III applications were taken from the Caltech/JPL Mark Series hypercube and ported to Mac-Cube. The algorithms used are described in detail in the book *Solving Problems on Concurrent Processors* (see reference 3). The two applications solve the Mandelbrot set in the complex plane, and a two-dimensional Laplace equation using finite-difference methods. Except for the graphical enhancements possible only on the Mac-Cube, the CrOS-based parts of the programs did not require any modifications to run in the Macintosh environment.

Although Mac-Cube is not designed for high performance, it does provide a speedup relative to the number of node computers. Figure 4 shows that the efficiency for solving the Mandelbrot set on a 1-cube (i.e., two Macs) is approximately 97 percent (speedup about 1.94 times) over that of a single Mac. This efficiency drops to 90 percent (speedup roughly 3.6 times) on a 2-cube (four-Mac) system.

Evaluating Value

Mac-Cube is valuable for learning hypercube programming and concurrent computation in general. It's inexpensive to set up and easy to install. The graphics and I/O capabilities of the nodes are particularly important for gaining insights into application development and problem solving, as well as for enabling users to actually look at each node of the hypercube in action.

The ability to watch the operation of each node also provides a good way to study parallel algorithm operation and makes debugging a simpler task. Applications implemented on the ark II/III series hypercube at Caltech/JPL have been ported to Mac-Cube with no relevant modification, demonstrating the compatibility of Mac-Cube's software environment with other hypercubes that use the Crystalline Operating System. ■

ACKNOWLEDGMENT

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DISK CACHING

Here's how to evaluate different disk-caching schemes

Personal computers have at last evolved to the point where computational speed is not the major source of delays. In most applications, the CPU spends the majority of its time waiting for one of two things: user input or peripherals (particularly disk transactions). It's unlikely that computer designers will be able to do anything to speed up the former, but they have done something about the latter. Taking advantage of increasingly inexpensive and quick DRAM, engineers are speeding up disk access by implementing hard disk caching.

RAM Caching vs. Disk Caching

A cache is a small amount of fast memory that holds the same information as some part of a slower storage medium, so that the information can be obtained quickly when it's needed. Most of the same terminology applies to RAM and disk caches: *hits*, *misses*, *lines*, and *associativity*. But because the physical and electrical characteristics of a hard disk are very different from those of a RAM chip, the optimal caching strategies are different as well.

The most important difference between disk and RAM caches, other than raw speed, is that not every byte of disk data is as easy to get to as every other byte. In most RAM systems, access times are the same for every byte. On a disk, the time it takes to retrieve an arbitrary byte can vary by two orders of magnitude (see the text box "What Affects Access Time?" on page 298).

Another important difference between disk caching and RAM caching is the size of the transfers involved. A RAM access on a typical microcomputer can retrieve as little as 1 byte; disk data must be accessed as whole sectors (typically 512 bytes, although some disks have 256-byte or 1K-byte sectors). This means that the minimum practical *line size* of a disk cache (i.e., the smallest chunk of data it can save for future access) is an order of magnitude larger than for a RAM cache.

Finally, there is the problem of maintaining *coherence*: keeping the contents of the slower storage medium the same as (or, in Unix parlance, in sync with) the cache. RAM is generally expected to be volatile. If you turn off the power switch on a machine with a RAM cache, you don't expect the contents to be preserved when you turn the machine back on. Thus, if a RAM cache doesn't get a chance to update main memory before the machine shuts down, it's not a problem. But it *is* a problem if your disk cache doesn't update the disk before you switch off. Whole files—and, worse yet, the directory structure of the disk itself—can be damaged or utterly lost.

Write-Through vs. Write-Back

Most cache programs used in microcomputers are *write-through* caches, maintaining coherence by sending write requests to the disk controller immediately. This is the most fail-safe method. But the cache can often save time and head motion if it delays writes. This is the idea of a *write-back* cache, which consolidates writes destined for the same track and does several at one time. If two write requests come in for the same sector, the cache can detect the situation and do only one write.

Delayed writes can cause problems, however. Early versions of Unix had a built-in disk cache that could delay writes for long periods. In fact, a sector that was written to frequently might not be updated for hours. If such a machine was shut down without a special command (called sync) or if it crashed suddenly, the file system could require major repairs. Fortunately, newer versions of Unix automatically do a sync at frequent intervals to avoid this problem.

Many cache programs that do delayed writes on other machines use a similar approach. The cache program I use on my IBM PC AT clone always flushes its cache after 2 seconds. It also intercepts the Ctrl-Alt-Del soft reset sequence and the INT 19 (Reset) vectors, and it makes sure that the disk gets updated before the machine is reset. It's not possible to trap a hard reset, however. Thus, if the machine crashes so badly that you need to reach for the big red switch or if you turn it off too quickly, you may lose data.

Read-Ahead

Just as it may be able to consolidate write operations by introducing a delay, a disk cache may be able to save time by implementing *read-ahead*—that is, reading into the cache for future use the sectors immediately after those requested by the operating system. Since disk access is often sequential, there's a good chance that this strategy will pay off.

The most simpleminded read-ahead algorithms do nothing more than increase the line size of the cache (i.e., always reading some additional number of sectors after the one requested). But smarter caches have more clever strategies. There's always a chance that an anticipatory read won't have any benefit, so it doesn't make sense to keep "extra" sectors in the cache until a least recently used (LRU) algorithm kicks them out. Instead, many caches reserve a separate portion of RAM exclusively as a read-ahead buffer and transfer only sectors that are really used to the main cache area.

Concurrent Operation

One thing that a cache can do—whether it's implemented as a caching controller or as software—is let disk operations

continued

Know Thy System

A good cache will take advantage of special knowledge of the operating system under which it runs. A DOS cache, for instance, may recognize that sectors are allocated in groups called *clusters* and

A disk cache is more essential in some operating environments than in others.

try to cache whole clusters (since that's the way DOS allocates and uses them). It should also know about and be able to use the different methods of allocating memory outside the limited 640K-byte DOS area, including LIM/EMS memory and the extended memory specification.

Familiarity with the file system is also useful. For instance, if a file is fragmented, read-ahead operations may be of no help; the next sector of the disk won't be the next sector of the file. But if the cache understands the file system well enough to find and read the sector that really *does* come next, it can do the right thing.

A disk cache is more essential in some operating environments than in others. The Amiga file system, for instance, is organized in such a way that reads and writes are relatively quick, but building a directory or locating a file can be very slow, even with the new, fast file system. A disk cache is important for good performance in this system.

As the user of a disk cache, you will need to know about the operating system as well, so that you can tune the machine for optimal performance. For instance, if you're running MultiFinder on the Macintosh, you may find it necessary to reduce the size of the cache to run many programs at once. Otherwise, the Resource Manager may continually purge resources from memory and then reread them from the cache, bogging down the system in the process.

Listing 1: *The 8086 assembly language source code for capturing a record of all the disk reads and writes.*

```
; ******************************************************************
; SNOOP.ASM                        Created 6 / 24 / 1989 by L. Brett Glass
; ******************************************************************
; This TSR logs all hard disk reads and writes that pass through
; the IBM PC BIOS to a RAM buffer. The sector, cylinder, head, drive,
; operation, and number of sectors are recorded.
;
; Usenet: apple!well!rogue
; ARPANET: well!rogue@APPLE.COM
; BIX: glass
; CompuServe: [72267,3673] (Also reachable from MCI Mail)
;
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; purpose, nor for consequential damages that may arise from its use.
;
; ******************************************************************
;
DISKINT    equ 13h ; Disk I / O interrupt number
DOS        equ 21h ; Interrupt number for: DOS function
TSR        equ 27h ;                       Terminate / stay resident
GETVEC     equ 35h ; DOS function numbers: Get interrupt vector
SETVEC     equ 25h ;                       Set interrupt vector
PRINTMSG   equ 9   ;                       Print message
HARD       equ 80h ; Mask to test for hard disk number
DISKREAD   equ 2   ; BIOS functions: Read
DISKWRITE  equ 3   ;                 Write
GETBUFADDR equ 99AAh ; Special Int 13h request for snoop buffer address
BADCMD     equ 1   ; Bad command result code for BIOS call
SENTINEL   equ 4321h ; Sentinel value to signal that SNOOP is present

MAXTRANSACTIONS equ 8 * 1024  ; Log 8K disk transactions
BUFFERSIZE equ 6 * (8 * 1024) ; Each transaction is 6 bytes

Code        segment
            assume cs:Code,ds:Nothing
            org 100h
Entry:      jmp near ptr Init ; Jump to transient portion of program
;
; Store the original vector here
;
DiskIO      label   dword   ; Make a label for the whole vector
DiskIOOfs   dw 0 ; Now make labels for segment and offset
DiskIOSeg   dw 0
;
; Define constants that indicate where buffer starts and ends
;
BufferStart equ (offset NextLoc) + 2
BufferEnd   equ   (offset NextLoc) + 2 + BUFFERSIZE
;
Snoop       proc far
            test dl,80h ; Is it a call to the hard disk?
            jz Chain    ; Nope, let it through
            cmp ah,DISKREAD ; Is it a read request?
            je Log      ; If so, log it
            cmp ah,DISKWRITE ; Is it a write request?
```

Caching and Networks

If you're running a LAN, you will almost certainly want to use a hard disk cache on the server. Novell's NetWare has caching built in, and some NetBIOS-based networks (e.g., the Network-OS) come with a disk-cache program that's relatively easy to install. Novell also has drivers for caching controllers.

Caches on network workstations are another matter. There is a great danger of losing coherency if two workstations have access to a file at the same time. To prevent this problem, most software hard disk caches will refuse to cache a network disk, leaving this task to the network software. The network software, which understands the protocols and file sharing conventions, generally takes a conservative approach as well—usually, it won't let a file be cached locally unless it's marked read-only or opened for the exclusive use of one workstation.

Hardware or Software?

If you're buying a new computer system, you may be faced with the dilemma of whether to buy a caching disk controller (like recent offerings from Distributed Processing Technology or Mylex) or simply use a software caching program.

Caching controllers certainly have some advantages: They add dedicated processing power to the system and usually don't take much (if any) RAM away from the host system. Unfortunately, they don't always deliver performance

```
            je Log
            cmp ax,GETBUFADDR ; Is it a buffer address request?
            jne Chain    ; If not read or write or addr request, pass on
GetAddr:    mov  ax,cs   ; Get address
            mov  es,ax
            mov  bx,offset WrapFlag
            mov  dx,SENTINEL ; Tell program SNOOP is present on the sly
            mov  ah,BADCMD ; Look like bad command
            stc          ; Generate apparent error
            ret 2        ; Do not restore original flags when returning
Log:        push di      ; Use di as a pointer into the buffer
            mov  di,cs:NextLoc ; Get the next position to be written
            mov  cs:[di],dx ; Store DX there
            add  di,2
            mov  cs:[di],cx ; Then CX
            add  di,2
            mov  cs:[di],ax ; Then AX
            add  di,2
            cmp  di,BufferEnd ; End of buffer?
            jb   @F
            mov  di,BufferStart ; If so, wrap to beginning
            mov  cs:WrapFlag,1 ; And set a flag so we know we've wrapped
@@:         mov  cs:NextLoc,di
            pop  di
Chain:      jmp cs:[DiskIO]  ; Jump to disk BIOS
Snoop       endp
;
; Labels used by TSR portion of program
;
WrapFlag    db   0 ; Flag to indicate buffer has wrapped at least once
NextLoc     label word ; Next location to store disk info
;
;           "Transient" area (also used for logging transactions) begins here
;
Message     db 'Hard Disk Log Utility'
            db 0Dh,0Ah,'Copyright (C) 1989 by L. Brett Glass'
            db 0Dh,0Ah,'Reboot to remove this TSR.'
            db 0Dh,0Ah,'$'
;
;           assume cs:Code,ds:Code
;
Init        proc near        ; This code executed on entry
            mov ax,(GETVEC shl 8) + DISKINT  ; Get interrupt vector from DOS
            int DOS          ; DOS call
            mov [DiskIOOfs],bx ; Save the old vector
            mov [DiskIOSeg],es
            mov dx,offset Snoop ; Get ready to add our own routine
            mov ah,SETVEC    ; Set interrupt vector through DOS
            int DOS          ; DOS call
            mov dx,offset Message ; Prepare to print message
            mov ah,PRINTMSG  ; Print message through DOS
            int DOS          ; DOS call
            mov NextLoc,BufferStart ; Start from beginning of buffer
            mov dx,BufferEnd ; Reserve space for buffer
            int TSR          ; Terminate and stay resident
Init        endp
Code        ends
            end     Entry
```

commensurate with their price tags, especially under single-tasking operating systems like DOS, where a software cache may be as good or better.

Hardware caches usually have their own pool of RAM for the cache, and you may need to buy special boards or chips from the manufacturer to expand the cache. (Software caches, by contrast, use the same kind of memory the rest of your machine uses, and you can usually decide how much RAM goes to the cache and how much to the system.) A caching controller may also prevent you from using low-level disk maintenance packages like SpinRite and Disk Technician. Caching controllers may prevent you from running operating systems that don't use the BIOS (e.g., Unix and OS/2) unless they're register-compatible with the original AT controller or come with a special software driver.

When evaluating a caching controller, beware of manufacturers' claims of "0.5-millisecond access time" or less. These figures are usually produced by benchmark programs designed to measure the time it takes for a hard disk drive to physically move its heads—*not* controller performance or overall system throughput. Since most caching controllers don't actually move the head in response to a seek command or do seeks in the background after the call has returned, the figure you'll get from one of these programs has little bearing on the performance you'll get on a day-to-day basis. If you wish to do a benchmark, use a set of tests that corresponds to the kinds of disk transactions you're likely to use in your work.

A Hard Disk Snoop

How would different disk-caching strategies affect performance on your machine? To demonstrate how hard disk caching could speed up your system, I've included a program that will let you find out. It consists of two parts: a TSR *snoop* module, which invisibly logs the last 8192 requests your machine has made onto the IBM PC disk BIOS, and a *simulator*, which shows how much time could be saved by different caching strategies. Listing 1 shows the assembly language source code for the TSR module.

SNOOP.COM installs itself between the Int 13h interrupt vector and the disk BIOS, and it logs all hard disk read and write requests. (It detects and ignores requests that go to floppy disk drives.) It saves 6 bytes of information about each request—including the action, the head, the track, and the sector—in a circular buffer for use by the simulator.

EVAL.PAS, the simulator, is written in Turbo Pascal 5.5. It looks through RAM and extracts the relevant information from the buffer maintained by SNOOP.COM and then analyzes it to see how a cache could speed up the system. You can enter different drive characteristics (e.g., interleave factors and access times) to see how the system will perform under different conditions.

EVAL.PAS is designed to make it easy for you to try your own disk-caching algorithms to see how well they would work with your machine and access patterns. If you have a clever idea for a replacement strategy, head-motion strategy, or some other improvement to disk-caching technology, here's your chance to find out how well it will work. Add the algorithm to the simulator and watch the results! ■

Editor's note: *The source code listing for SNOOP.ASM and EVAL.PAS is available in several formats. See page 5 for details.*

L. Brett Glass is a freelance programmer, author, and hardware designer residing in Palo Alto, California. He can be reached on BIX as "glass."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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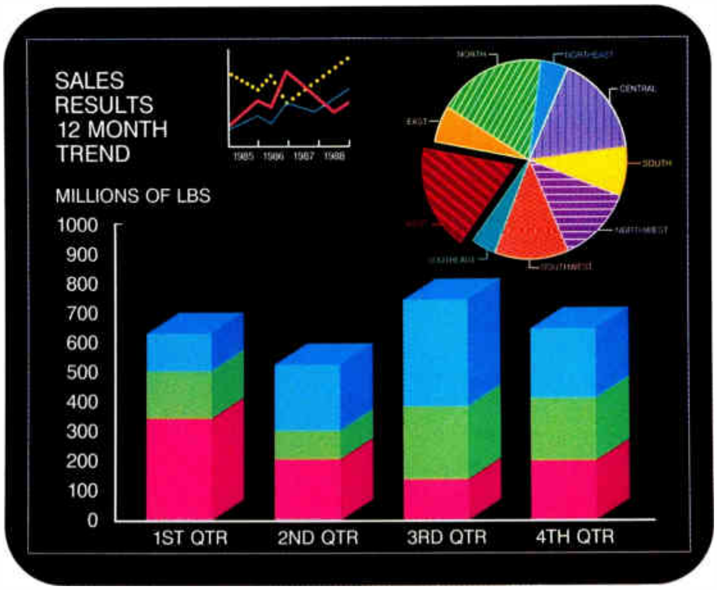

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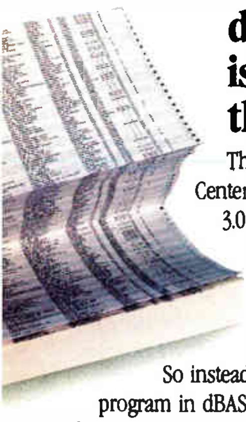

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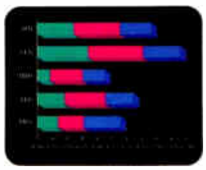

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Part 1

TWO TIN CANS AND SOME STRING

A two-part series on AppleTalk and NetBIOS, and how each works with a file transfer program

Networks have snuck up on us. I can't remember how many times I've read or heard about "The Year of the LAN." I don't think there ever will be a Year of the LAN; the invasion moves like a sluggish tide: imperceptible but overwhelming. Here at BYTE, there are at least three LANs in operation (that I'm aware of), and they were all installed without fanfare or massive work interruptions: A phone man showed up one day to put a red sticker on my new outlet; a board and some cables showed up the next day. I was connected before I knew what was going on.

What has amazed me most about networks is how underutilized they often are. It wasn't until more than a year after installing AppleTalk that I finally shouldered my way into the *Inside AppleTalk* manual and realized that I already had services available for creating applications beyond simply sharing the laser printer. Later, after I'd installed one of the serial-card-based LANs (EasyLAN, to be exact) in two of my PC clones, I discovered that I could put together NetBIOS applications. It was like learning two languages that had sprung from a common ancestor but had developed in separate cultures (Apple and IBM).

I decided that the best way to present AppleTalk and NetBIOS was to concoct a real-world application as a common denominator and then build software to perform the task—one program using AppleTalk, the other using NetBIOS. The job—simple and useful—is transferring a file from one machine on a network to the other. Not a contest, more like a shared stage. And I'll start the performance with the AppleTalk program.

What's Your Address?

When you think about what a network is—a bunch of computers and printers sharing some form of common communications medium—you realize that one logistical problem that crops up is how to give users the ability to recognize one another. This boils down to providing each user with a unique address that other users can identify. On an AppleTalk network, each machine is assigned a unique, 8-bit *node* number. (I'll reveal which program does this assigning later.) Notice I said "each machine," not "each computer." A machine on a network can be an unmanned peripheral (e.g., a laser printer) as well as a manned Macintosh.

On a single Mac, I might run more than one application that's using the network. For example, I might run a DBMS program reading a shared database on some remote server to generate a sales report on the office laser printer. How does the network keep records arriving from the database server from getting mixed up with acknowledge packets from the printer, even though both are being sent to the same node (i.e., my machine)?

Sockets is the network term for the answer. A socket is a kind of logical node within a node, a post office box within an apartment number. Each application wishing to communicate across AppleTalk must first obtain an 8-bit socket number that is unique within the node. For this reason, a program that communicates across the network is often called a *socket client* (used interchangeably with the term *network-visible entity*). So, in the example above, my DBMS program might be communicating with the server via socket 64, while the print job is talking to the LaserWriter through socket 65. Messages coming back from the server say "Deliver me to socket 64," while acknowledge packets from the printer say "Deliver me to socket 65."

Finally, AppleTalk permits you to connect networks via bridges to form internets. AppleTalk allows up to 254 unique nodes on a single network. If bridging were not allowed, some large installations would quickly reach the limits of AppleTalk. To distinguish one network from another, AppleTalk defines a 16-bit network number associated with each network on an internet.

These three coordinates—network number, node number, and socket number—combine to form a socket client's *internet address*. This address is unique for each socket client on an internet.

Level Out

The components of AppleTalk are stratified in clearly defined layers (see the figure on page 149 of the July BYTE). Each layer is really nothing more than a set of functions. But it's convenient to speak of layers, because this helps you visualize the fact that functions of higher layers embody more complex activities. Also, functions in higher layers stand on the shoulders of those below: Functions of one layer can only call functions beneath them. It's important to point out, however, that layers are not opaque; those above do not hide those below. Programmers have full access to all layers, so if you don't like the way Apple has done things, you can literally write your own network operating system from the ground up.

• *ALAP*. The lowest of these layers is AppleTalk's Link Access Protocol. ALAP is the gateway through which everyone must pass to get to the actual network. It's also the AppleTalk traffic cop; since AppleTalk is physically a CSMA/CD network, it's ALAP's job to

continued

resolve collisions on the network. Basically, this means that everyone talks along the same wire, and if two users talk simultaneously, a collision occurs. ALAP, in the case of AppleTalk, detects the collision and handles retransmission.

Recall that machines on an AppleTalk network are recognized by unique node numbers; ALAP enforces that uniqueness. Packets traveling along the network are referred to as ALAP frames. These frames contain source and destination node numbers so that every machine can determine who's talking to whom.

ALAP is described as a "best effort" delivery system. This means that if you send a data packet from one node to another using ALAP calls, you're not guaranteed that the message will arrive safely at its destination. If some transmission error occurs along the way, the destination node will detect the error (since ALAP attaches a 16-bit frame check sequence). However, ALAP contains no accommodations for retransmitting the bungled packet—that's the job of higher-level protocols. ALAP makes certain only that it got sent—not that it arrived.

• *DDP.* Next up the ladder is the Datagram Delivery Protocol, which manages communications between sockets on an internet. DDP recognizes sockets within nodes, but, as with ALAP, it only provides a one-shot attempt; if the packet's contents are somehow fouled, DDP will make no attempt to resend. This is where ATP comes in.

• *ATP.* The AppleTalk Transaction Protocol, as its name implies, provides a controlled means of carrying out a complete transaction between two socket clients on the network. A *transaction* is AppleTalk for a dialog: the exchange of a request and a response between two application programs (see figure 1). A response can actually consist of up to eight transmissions. So, a single requesting transmission might be a message like "Send me the first eight 512-byte blocks from file BOB." The response would consist of eight actual packets that are consecutive 512-byte blocks from BOB.

ATP guarantees delivery. Application developers don't have to worry about calculating cyclic redundancy checks or what to do if one end drops a packet. This month's sample program uses ATP for that reason. The guarantee is possible because of the transaction ID that ATP attaches to outgoing request packets. When a respondent services the request, the response packets sent back to the requester carry that same transaction ID.

The ATP driver also holds a retry timer and maximum retry count. Once a request datagram is sent, ATP starts the retry timer. If the requester doesn't receive a response before the timer runs out, ATP retransmits the request. The retry count specifies how many times ATP should attempt retransmission. If you're bound and determined to get a request to its destination, you can specify a retry count of 255, which tells ATP to continue retransmission forever, until you explicitly tell it to stop (or until it succeeds).

ATP provides two classes of service: ALO (for "at least once") and XO (for "exactly once"). If you flag an ATP request as being ALO, then *any time* the request is received by the responder, the responding system's ATP driver will deliver that request to whatever application is calling ATP. So, even if the requester's ATP driver retransmits the same packet as part of a retry operation, that packet is delivered to the responder. This is useful for time-critical applications where one machine is monitoring a rapidly changing value (such as a timer) on another machine.

XO transactions allow only one copy of the request packet to make it to the responder's end, no matter how many times a request may have been retransmitted. (XO transactions are sufficient for most applications; this month's program uses them exclusively.) Each responder's ATP driver maintains a list of recently received XO transactions, so ATP can determine which transactions have already been sent to the calling application.

You Name It

Now that you've learned what facilities are available for setting up communications between two Macs, there's probably a question nagging at you: "How does a program on one Mac 'find' a program on some other Mac in order to set up communications?" Well, remember

continued

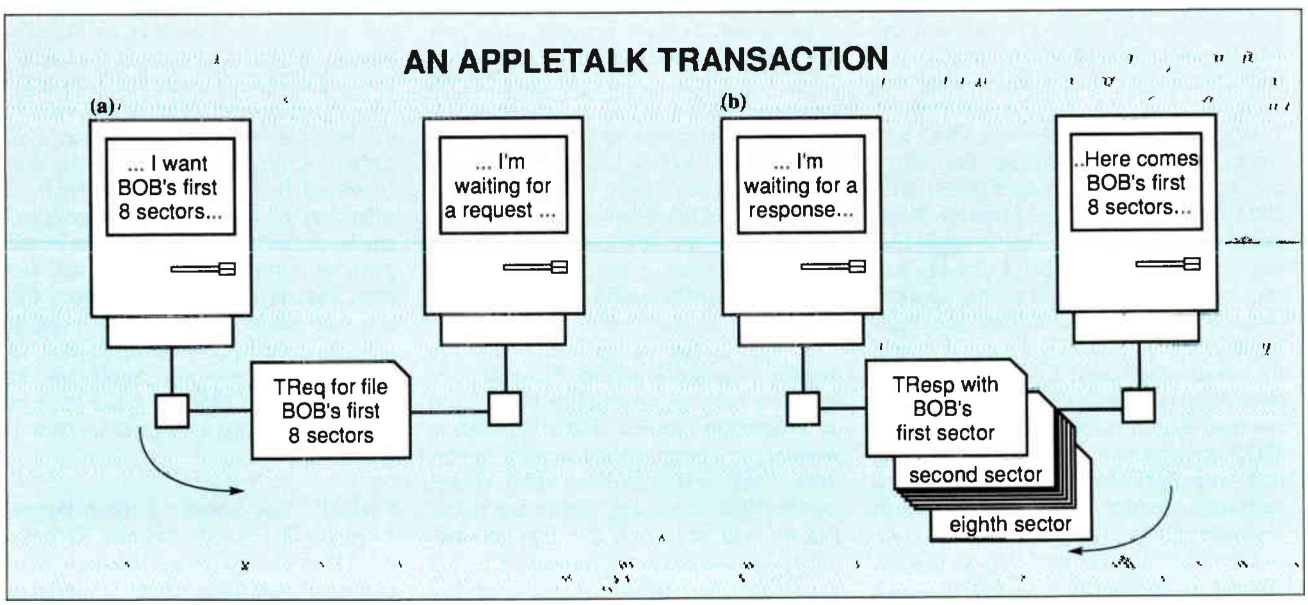

Figure 1: *The anatomy of a transaction.* **(a)** *The system on the left sends a request (TReq) to the system on the right. The request is for the first eight sectors of a file.* **(b)** *Since a single request can be answered with up to eight responses, the system on the right is able to satisfy the request with eight response (TResp) packets.*

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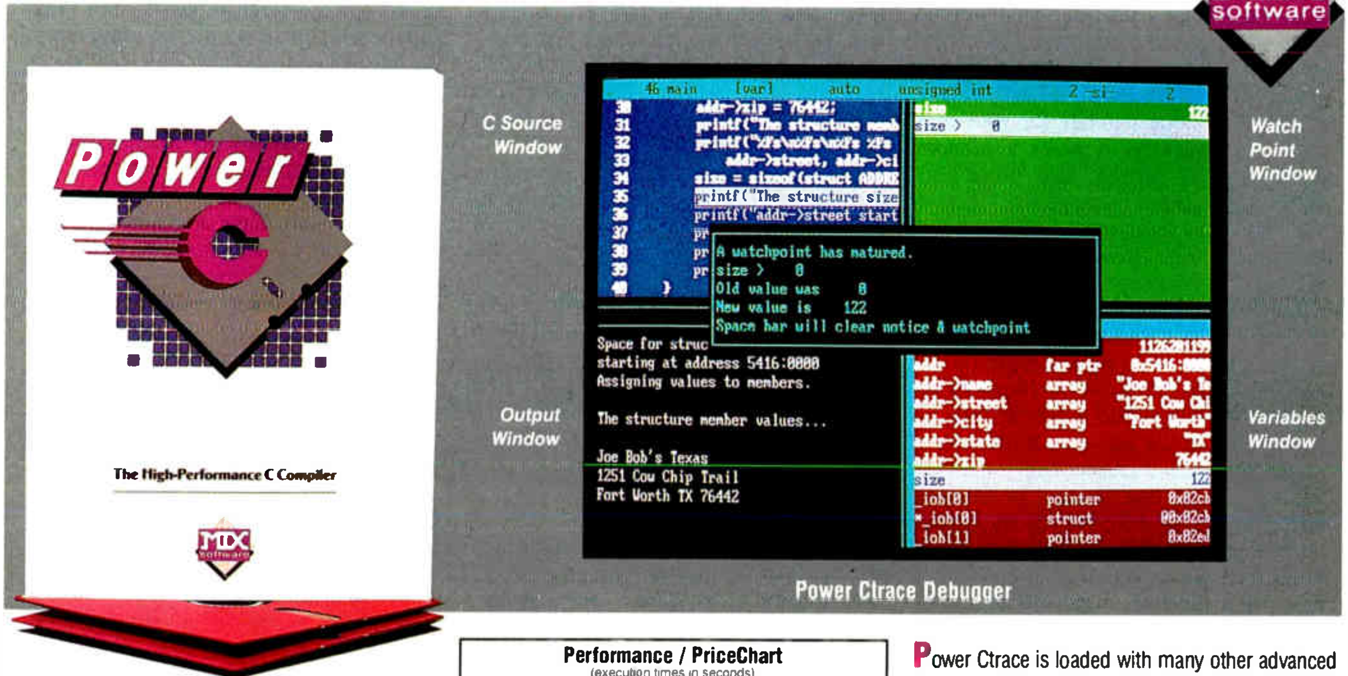

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that it's ALAP's job to assign unique node numbers to machines on the network. When you activate AppleTalk on your Mac, your local ALAP driver chooses the node number for your machine dynamically. It picks a random node number, say 88, and broadcasts onto the network a message like "I want to be node 88; are there any objections?" If a machine is already node 88, your ALAP driver keeps picking random numbers until there are no complaints.

Even though the node numbers are random, your machine locates your partner's machine thanks to the Name Binding Protocol. The NBP makes socket clients visible on the network. It provides a means by which a socket client's internet address can be tied (*bound*, in network terminology) to a name. Most important, once you've bound your internet address to a name, you can register that name in a kind of network-wide directory that all network users have access to. Then anyone who knows your internet name can find your internet address.

A name consists of three components: zone, type, and object. Each component can be up to 32 characters long. The zone portion lets you partition an AppleTalk internet into subnets—handy for setting up departments in a large, companywide network. The type component lets you identify the kind of service an entity provides. Finally, the object portion lets you distinguish between members of the same type in the same zone.

Here's an example: This month's program runs on two machines—the one sending the file and the one receiving the file. Both machines call NBP and register their types as "BYTEFTRANS." However, the sender's object name is "ByteSend," and the receiver's object name is "ByteRecv."

Once a program registers its name on the network, applications on other machines can use NBP to locate the internet address of that program. Notice I said *program* and not *computer*. Remember that machines are associated with nodes, while programs are associated with sockets within nodes. So, a single machine may have several names registered on the network, each name attached to a particular application program running on that Macintosh.

Establishing a Dialogue

To make all this clear, I'll step through the AppleTalk calls that a program would use to send a file across the network. Imagine that you want to send a document from your Mac Plus to a colleague's Mac II across the office. In keeping with ATP terminology, assume your machine is the requesting end and your comrade's is the responding end, and assume both ends are running the same program. (This program is general enough to act as either sender or receiver.)

The program's first task is to make each end of the conversation visible to the other. This is a job for NBP, but before you can call it, you have to have an internet address with which to bind the name. On the responder's side, the program calls the `OpenATPSkt` function to open a socket for receiving requests. You must supply this function with two arguments: the internet address from which to expect requests, and the socket number on your node (the local socket) that will receive them. If you give the function a 0 for the local socket number, ATP will pick the socket number for you.

The internet address argument defines the requester's side of the transaction and acts as a filter for incoming requests. Remember that an internet address consists of network number, node, and socket. If you enter a nonzero number for any component of the internet address, your program receives only those transactions matching that value in that component. If you've constructed a networked database server, you might set its local socket to 89 and set the requester's socket to 89, and all network traffic pertaining to your database will occur only between applications talking through socket 89.

A zero in one of the requester's internet fields matches all requests in that field. Thus, if you pass `OpenATPSocket` all zeros for the requester's internet address, you've told ATP that the local socket will accept requests from anyone on the network. (Sockets 64 through 127 are available for applications to use. ATP uses socket numbers between 128 and 254 when it picks the number. Sockets 0 through 63 are reserved by Apple.)

Moving up to NBP

Now that the responder has opened a socket, the program can call the NBP

continued

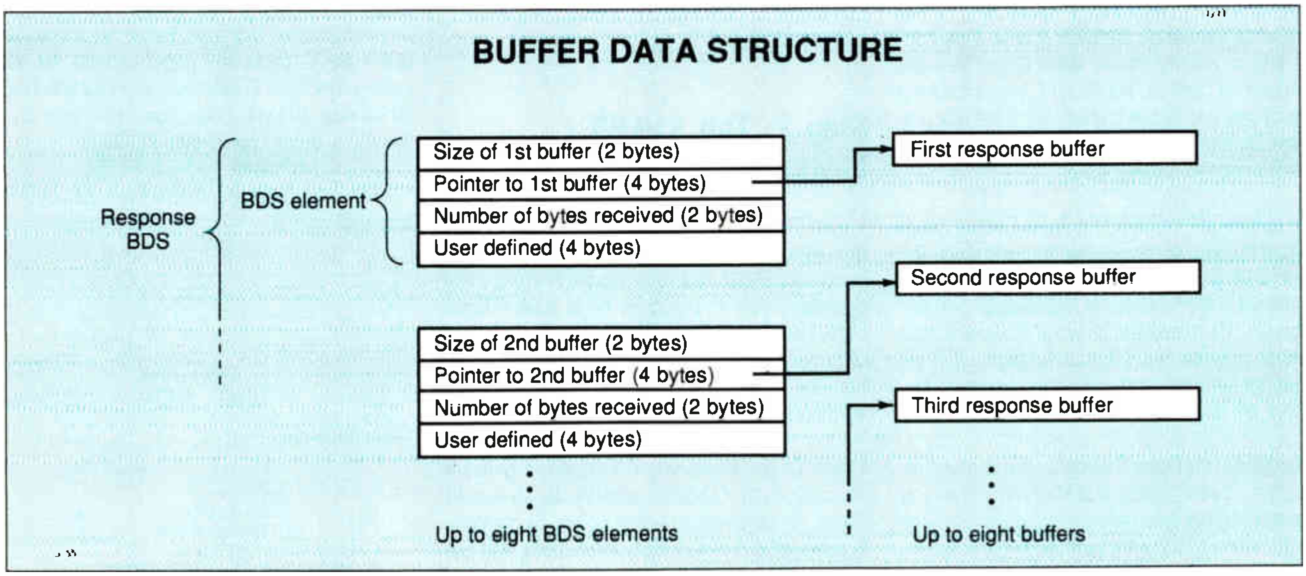

Figure 2: *The response buffer data structure (BDS) tells the AppleTalk Transaction Protocol where incoming responses can be placed. A single response BDS can consist of up to eight BDS elements of 12 bytes each. A BDS element governs a response buffer, where the actual response data goes.*

Listing 1: *Pseudocode for a program to send and receive a file on an AppleTalk network.*

```
IF receiving THEN direction:=1
      ELSE direction:=0;
{ Prompt user for filename.
IF direction=1 THEN
 BEGIN
  Display an SFPutFile Dialog Box;
  fname := entered filename;
 END
ELSE
 BEGIN
  Display an SFGetFile Dialog Box;
  fname := selected filename;
 END

{ Open an ATP socket.
{ Following lines tell OpenATPSocket that the local
{ socket (selected to be 89) will receive requests from
{ all network addresses, nodes, and sockets. Hence zeros
{ in each field.
IN Parameterblock DO
 BEGIN
  receive_network_address = 0;
  receive_node_number = 0;
  receive_socket_number = 0;
  mysocket = 89;
 END
CALL OpenATPSocket(Parameterblock);

{ Register your name on the network.
zone := "*"; { Local zone
type := "BYTEFTRANS";
IF direction=1 THEN object := "ByteRecv"
               ELSE object := "ByteSend"
mysocket := 89;
Build a Names Table Element;
IN Parameterblock DO
 BEGIN
  Set pointer to Names Table Element;
  retry_interval = 10; { Retry every 1.3 seconds
  retry_count = 50;
  verify_flag = TRUE;  { Check for duplicate names
 END
CALL NBPRegisterName(Parameterblock);

{ Look up the other station's name.
zone := "*";
type := "BYTEFTRANS";
IF direction = 1 THEN object := "ByteSend"
                 ELSE object := "ByteRecv";
Build an Entity Name;
IN Parameterblock DO
 BEGIN
  retry_interval = 10; { Retry every 1.3 seconds.
  retry_count = 50;
  Set pointer to Entity Name;
  { Set aside 40 bytes to receive response from
  { LookupName().
  ret_buffer = NewPtr(40);
  ret_buffer_size = 40;
  max_to_get = 1;   { Looking for 1 name.
 END
CALL LookupName(Parameterblock);
{ LookupName returns numGotten in Parameterblock.
IF numGotten = 0 THEN
 BEGIN
  Display(" **No answer")
  CALL REMOVE_MY_NAME;
  EXIT
 END
{ If LookupName() was successful, the other
{ side's internet address is in ret_buffer.
EXTRACT his_address from ret_buffer;
Free(ret_buffer);  { Dispose of memory used by ret_buffer.

{ Both ends must build a response buffer data
{ structure-referred to as a BDS. See text for
{ details.
Build a response BDS;
IF direction = 0 THEN
BEGIN
 Open(fname);
 offset := 0;
 WHILE (fname NOT at end-of-file)
 BEGIN
  { Read 512 bytes from file fname into buffer, leave
  { the first 2 bytes of buffer empty.
  Read(fname,buffer[2],512);
  { Set the first 2 bytes of buffer to the number
  { of bytes actually read by Read().
  buffer[0..1]=number_actually_read;
  IN Parameterblock DO
   BEGIN
    Set exactly_once bit;
    addr_block := his_address;
    req_length := 514;
    req_pointer := buffer;
    Set bds_pointer to our response BDS;
    { We expect only 1 response.
    num_of_buffs := 1;
    timeout_val := 15; { Retry every 15 seconds.
    retry_count := 4;  { Retry 4 times.
   END
  CALL SendRequest(Parameterblock);
 END { End of WHILE loop }

ELSE  { direction = 1 }
 BEGIN
 Create(fname);  { Create the file.
 REPEAT
  { Get a request.
  IN Parameterblock DO
   BEGIN
    atp_socket := 89;  { Receive on socket 89.
    req_pointer := buffer;
    req_length := 514;
   END
  CALL GetRequest(Parameterblock);
  { GetRequest() returns a transaction ID in the
  { Parameterblock...I'll call it transaction_ID.

  { The number of bytes sent is in the first 2 bytes
  { of buffer.
  num_bytes := buffer[0..1]...;
  IF num_bytes<> 0 THEN
    Write(fname,num_bytes,buffer[2]);
  { Send a response.
  IN Parameterblock DO
   BEGIN
    atp_socket := 89;
    { Show that this is the last response
    { to the current request.
    atp_flags := atpEOMBit;
    addr_block := his_address;
    Set bds_pointer to our response BDS.
    { Only 1 response to send.
    num_of_buffs := 1;
    bds_Size := 1;
    trans_ID := transaction_ID.
   END
  CALL SendResponse();
 UNTIL (num_bytes <> 512); { End of REPEAT.
 END

{ Finish up.
 Close(fname);
 Display("Done");
 CALL REMOVE_MY_NAME;
 EXIT;

REMOVE_MY_NAME:
 zone := "*";  { Local zone
 type := "BYTEFTRANS";
 IF direction=1 THEN object := "ByteRecv"
                ELSE object := "ByteSend"
 { An entity_name is simply a concatenation
 { of zone, type, and object, with each string
 { preceded by a byte count.
 entity_name := zone + type + object;
 IN Parameterblock DO
   entity_pointer := address of entity_name;
 CALL RemoveName(Parameterblock);

 RETURN;
```

function RegisterName to attach a name to that socket and make the name visible on the network. You don't have to explicitly tell NBP your node or network number; it can find that out itself.

The requester doesn't need to make all the calls to ATP or NBP that I've mentioned. Strictly speaking, the requester can sit back and watch the network for the responder's name to appear and then begin transmitting requests at the responder's internet address.

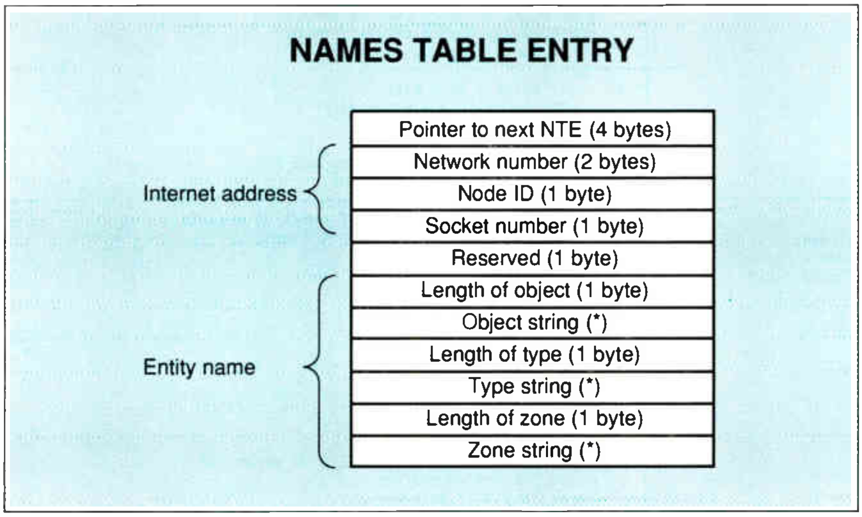

Figure 3: *The names table entry (NTE) list is the Name Binding Protocol's in-memory notebook of what names are currently active on the network. Each NTE is composed of two parts, the entity's internet address and name. (Fields with asterisks are variable-length, with size determined by a preceding count byte.)*

However, in my file transfer program, I opted to have the requester call OpenATPSocket to capture a socket for the sole purpose of having one to give to RegisterName. In this way, both ends of the conversation can see that the other is on the network. So the requester's name serves merely as a semaphore to the responder's program, telling it that the requester is active and communication can commence.

The NBP routine LookupName allows a program to see visible entities on the network. You pass this routine a pointer to a data structure containing the three components (zone, type, and object) of a target name, and LookupName rummages around on the network and returns another data structure containing the internet address of all entities that match. Each component can contain wild-card characters: "*" in the zone field means the caller's local zone (similar to a default directory in a file open command); "=" in the type or object field tells LookupName to match all possible values for that field. This lets you locate all network entities in your zone of type "Database," for example.

In my file transfer program, the requester calls LookupName to search in zone "*" for type "BYTEFTRANS" and object "ByteRecv." The program then examines the data structure that LookupName returns to determine the responder's internet address. Once the requester knows the responder's address, the requester opens the file you've selected for transmission and calls SendRequest to begin passing data sectors over the network.

As I mentioned earlier, the responder calls LookupName merely to convince itself that the requester is on-line. Once that's done, the responder calls GetRequest to receive the data transmitted by the requester's SendRequest call. The rest is a dance choreographed by AppleTalk: The request packet passes from requester to responder, and the responder writes the data to the disk and issues a SendResponse call to inform the requester to send the next packet. This process—SendRequest, GetRequest, and SendResponse—continues until the entire file has been transmitted.

The Job Is Done

Once the job is done, both sides close things down in an orderly fashion: Both

continued on page 357

 Circle 213 on Reader Service Card (DEALERS: 214)

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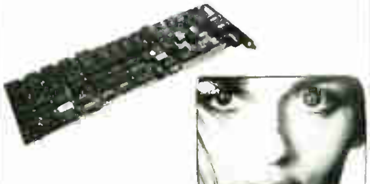

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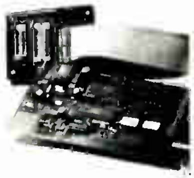

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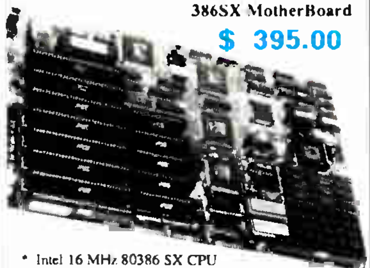

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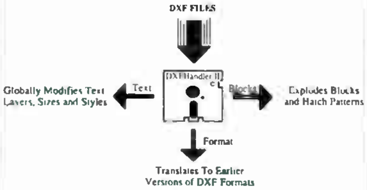

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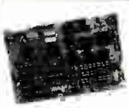

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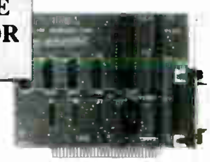

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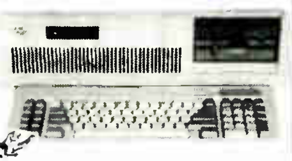

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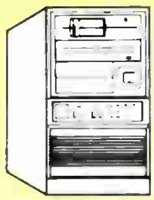

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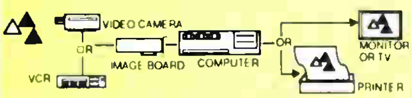

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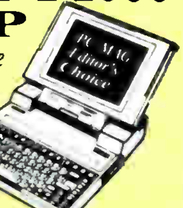

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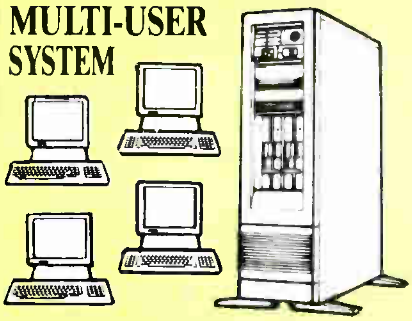

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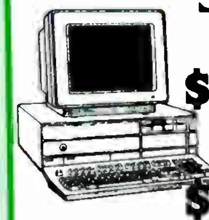

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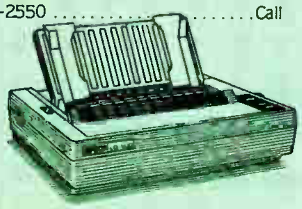

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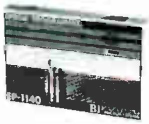

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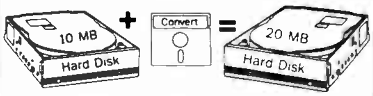

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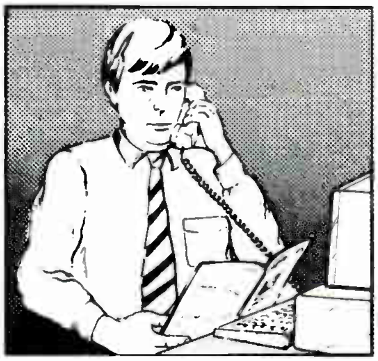

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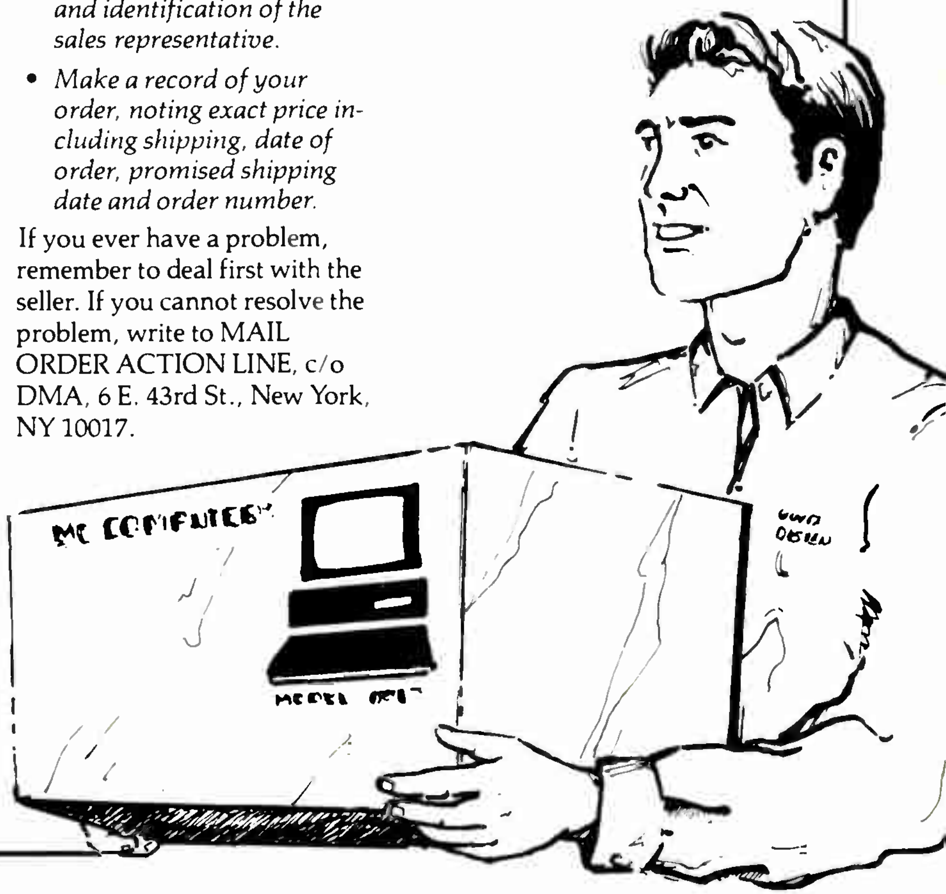

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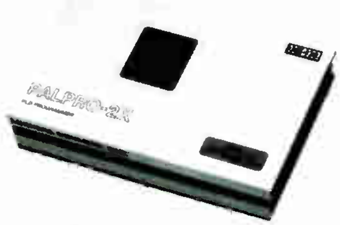

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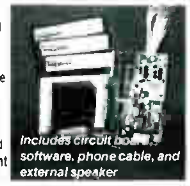

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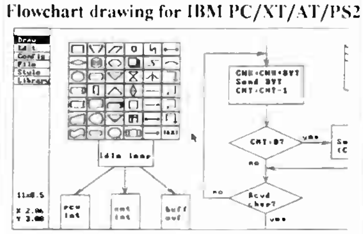

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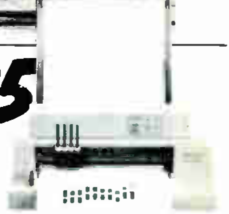

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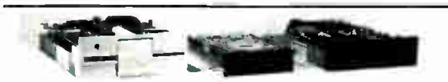

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MINISCRIBE 8425 25 M 65ms	239	227
MINISCRIBE 3650 50M 61 ms.	319	309
MINISCRIBE 6085 90 meg.	459	435
MINISCRIBE 3053 25 ms. ½ ht.	359	339
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FUJITSU 2243 86 M. 35mS.	1695	1619
RODIME RO-204E 53 Meg.	895	859
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41256-120	262144x1	120ns	16	4.99
41256-100	262144x1	100ns	16	5.49
41256-80	262144x1	80ns	16	5.99
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HM43256LP-12	32768x8	120ns	28	21.95
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This month's topic is floppy drive compatibility. There are 360K 5-1/4", 720K 3-1/2", 1.2Meg 5-1/4" and 1.44Meg 3-1/2" drives, any of which can be used on most PC's and PC clones. *Recent improvements in floppy controllers make using high density drives on 8088-based machines a viable option.*

To simplify, we'll eliminate the redundant choices. A 1.2Meg drive can work with both high density 1.2Meg floppies and low density 360K floppies.* A high density 3-1/2" 1.44Meg drive can use both the high density1.44Meg and the low density 720K disks. Unless you know that you will never need high density capability, a good universal standard is one 3-1/2" and one 5-1/4" high density drive.

Now for the bomb! Big Blue uses a different method to distinguish between 720K and 1.44Meg drives. While most of the manufacturers look for and detect the High Density hole in a high density diskette, they read the data to make that determination. This causes a problem when a Low Density disk without the hole is written in the high density mode. So if you get a 3-1/2" disk that a friend says is formatted at 1.44Meg, make sure it has a High Density hole or it probably won't read in your clone.

Derick Moore, Director of Engineering

*An infrequent problem can occur when a 360K drive is written in a 1.2Meg drive and is then read in a 360K drive.

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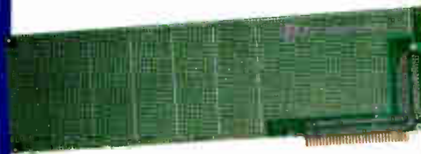

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2764-200	8192x8	200ns	12.5V	28	4.25
27C64	8192x8	250ns	12.5V	28	4.95
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27128A-200	16384x8	200ns	12.5V	28	5.95
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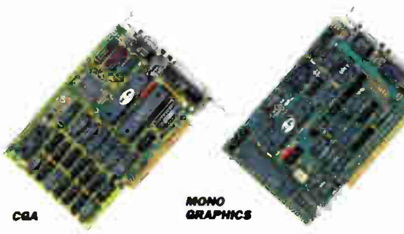

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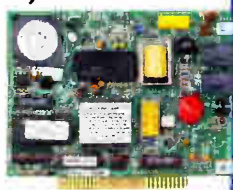

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EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue
Each reference is to the first page of the article or section in which the company name appears

INQUIRY # COMPANY PAGE

1141 AAPPS ... 49
989 ACCOLADE ... 115
982 ADVANCED GRAPHIC
1071 APPLICATIONS ... 133, 160, 266
1181
1147 ADVANCED PRODUCTS &
TECHNOLOGIES ... 49
AGILIS ... 17
1124 AJIDA TECHNOLOGIES ... 64
1002 ALDUS ... 81
1182 ALPHATRONICS ... 266
1121 AMERICAN IMAGING
SYSTEMS ... 64
855 AMERICAN MITAC ... 181
AMETEK ... 287
AMOCO LASER ... 249
1105 ANNABOOKS ... 64
APPLE
COMPUTER ... 98, 139, 149, 287
1183 AQUIDNECK SYSTEMS
INTERNATIONAL ... 266
986 ARITY ... 133
ASHTON-TATE ... 17
AST RESEARCH ... 17
AT&T UNIX SOFTWARE
OPERATION ... 17
ATARI ... 17

1116 BIOPAC SYSTEMS ... 64
BIPOLAR INTEGRATED
TECHNOLOGY ... 17
1104 BLAISE COMPUTING ... 64
860 BORLAND INTERNATIONAL ... 111
1131 BUSINESS FORECAST
SYSTEMS ... 64

CALTECH/JPL MARK ... 287
CANON ... 17
1118 CIMTECHNOLOGIES ... 64
COMPUTER PROFESSIONALS FOR
SOCIAL RESPONSIBILITY ... 17
1184 COMPUTER UPGRADE ... 266
1072 COREL SYSTEMS ... 160, 266
1152 CORVUS SYSTEMS ... 49
997 CRESCENT SOFTWARE ... 115
1139 CUMULUS ... 49

DATA GENERAL ... 17
DATA TRANSLATION ... 17
984 DAVE BRICCETTI AND
ASSOCIATES ... 133
DAVID SARNOFF RESEARCH
CENTER ... 239
1006 DAYNA COMMUNICATIONS ... 81
1144 DAYSTAR DIGITAL ... 49
1186 DELTA MICROSYSTEMS ... 266

INQUIRY # COMPANY PAGE

1187 DELTAIC SYSTEMS ... 266
1154 DIGITAL COMMUNICATIONS
ASSOCIATES ... 49
1134 DIGITAL EQUIPMENT ... 49

852 EASTMAN KODAK ... 191
994 ELECTRONIC ARTS ... 115
ENVIRONMENTAL PROTECTION
AGENCY ... 17
EPSON ... 17

FIFTH GENERATION SYSTEMS ... 17
1148 FRANKLIN COMPUTER ... 49
FUJITSU ... 17

1123 GENERIC SOFTWARE ... 64
1143 GENESYS ... 49
GEORGE MORROW ... 17
GEORGIA INSTITUTE OF
TECHNOLOGY ... 231
990 GROLIER ELECTRONIC
PUBLISHING ... 115

995 HAMMERLY COMPUTER
SERVICES ... 115
1133 HEADSTART TECHNOLOGIES ... 49
1115 HEM DATA ... 64
HEWLETT-PACKARD ... 17, 49, 81
983 HILGRAEVE ... 81, 133
1005
HITACHI/MAXWELL ... 17

854 IBM ... 17, 145, 181, 249
1101
IMC NETWORKS ... 17
1136 IMPRIMIS TECHNOLOGY ... 49
1073 INFORMATION
1188 STORAGE ... 160, 266
INTEL ... 17, 287
883 INTERACTIVE SYSTEMS ... 201
1130 ISOGON ... 64

JAPANESE ELECTRONICS
INDUSTRY & DEVELOPMENT
ASSOCIATION ... 17
1103 JENSEN & PARTNERS
INTERNATIONAL ... 17, 64

KNIGHTS TECHNOLOGY ... 249
KODAK ... 249
1112 KORN INDUSTRIAL
CONSULTANTS ... 64

1151 LAN SYSTEMS ... 49
1120 LANDCADD ... 64

INQUIRY # COMPANY PAGE

1074 LASERDRIVE ... 160, 266
1189
885 LOGITECH ... 64, 115, 195
991
1102
LOTUS DEVELOPMENT ... 17

988 MAGIC 7 SOFTWARE ... 115
884 MAPPING INFORMATION
SYSTEMS ... 211
MATE ... 17
1075 MAXIMUM STORAGE ... 160, 266
1190
1140 MEGAGRAPHICS ... 49
981 MICHTRON ... 133
MICRION ... 249
1191 MICRO DESIGN
INTERNATIONAL ... 266
998 MICROHELP ... 115
MICROSOFT ... 17
1192 MITSUBISHI ELECTRONICS
AMERICA ... 17, 266

1193 N/HANCE SYSTEMS ... 266
1129 NARDONI ASSOCIATES ... 64
NATIONAL EDUCATION
COMPUTING CONFERENCE ... 17
NCR ... 17
NCUBE ... 17, 287
1137 NEC HOME ELECTRONICS
(U.S.A.) ... 17, 49
NEWPORT ... 249
NEXT ... 17
1135 NORMEREL USA ... 49
NOVELL ... 149

1113 OCEAN ISLE SOFTWARE ... 64
OKI ELECTRIC ... 17
OLIVETTI ... 17
1194 ONLINE COMPUTER
SYSTEMS ... 266
993 OXFORD UNIVERSITY
PRESS ... 115, 360

1195 PANASONIC INDUSTRIAL ... 266
PAUL MACE ... 17
1008 PERCEPTIVE SOLUTIONS ... 81
1196 PERIPHERAL LAND ... 266
PHOENIX TECHNOLOGIES ... 17
1150 PHOTONICS ... 49
1076 PIONEER COMMUNICATIONS
1197 OF AMERICA ... 160, 266
PIXAR ... 249
POQET ... 17
PRIME ... 17
1155 PROTEON ... 49

INQUIRY #	COMPANY	PAGE
	QUESTEK	249
1077 1198	RACET COMPUTERS	160, 266
992	ROBERTA J. POURNELLE	115
1145	RUPP	17, 49
987	SAMNA	115
1138	SEIKO INSTRUMENTS USA	49
1000	SELECTRONICS	115
	SEMICON WEST	249
	SHARP	17
886	SILICON BEACH SOFTWARE	217
	SILICON GRAPHICS	249
1125	SOFTPRO	64
985	SOFTWARE DIRECTIONS	133
	SPECTRA-PHYSICS	249
	STANFORD UNIVERSITY	239
1078 1199	STORAGE DIMENSIONS	160, 266
980 1080	SUMMUS COMPUTER SYSTEMS	160, 266
1079 1200	SUMO SYSTEMS	160, 266
	SUN MICROSYSTEMS	17, 149
1003	SYMANTEC	81
	SYMBOLICS	17
851	TEKTRONIX	187
1149	TELESYSTEMS SLW	49
	TERADYNE LASER SYSTEMS	249
	TEXAS INSTRUMENTS	17
996	THE PROICON GROUP	115
	3-D SYSTEMS	249
	TOPS	149
853	TOSHIBA AMERICA INFORMATION SYSTEMS	17, 191
999	TRAVELER'S GUILD	115
1128	TSM ASSOCIATES	64
	U.S. COMMERCE DEPARTMENT	17
	UNISYS	17
981	UNITED SYSTEMS	266
	UNIVERSITY OF ALABAMA	231
1153	VADIS	49
1132	WELLS AMERICAN	49
1001	WORDSTAR INTERNATIONAL	17, 115
	WORDTECH	17
	XRL	249
	ZENITH DATA SYSTEMS	17

COMING UP IN BYTE

Scheduled to appear in forthcoming issues of BYTE, the following list of articles represents work in progress.

PRODUCTS IN PERSPECTIVE:

With TIGA-based graphics just around the corner, we test a number of graphics coprocessor boards using the Texas Instruments 34010 chip in the November **Product Focus**.

Diskless workstations are becoming popular for use in LANs. We compare two new units from Wyse Technology and TeleVideo Systems in **system reviews**.

In a **peripheral review**, we evaluate two high-speed network nodes from Dayna Communications and TOPS that claim to quadruple data transfer rates on Apple networks.

Software reviews look at the following two products: ExperTelligence's Action! is an applications development program that runs on the Macintosh II/Texas Instruments MicroExplorer combination, and Alpha Four from Alpha Software is a relational database designed for nonprogrammers.

IN DEPTH:

The November Expanded In Depth will explore the hardware and software capabilities, challenges, and problems associated with **32 bits and above**. This may sound futuristic, but it isn't, because 32-bit hardware is here in 80386, 68020, and 68030 machines. And as the 80486 is here now, can the 68040 be far behind? What are some of the challenges associated with bringing software to these machines that actually use their 32-bit capabilities? How do 32-bit systems handle memory? And where will they go from here? Is the direction onward and upward? 64 bits? 128 bits? Is there a limit? Do we reach a point of diminishing returns? These are some of the questions that will be answered.

FEATURES:

We'll take a look at **helical scan technology**, a method of storing data on magnetic tape that owes a great deal to the VCR. Additionally, we'll explore **Intel's new 80860 chip**, take a guided tour of the **NeXT machine's Mach operating system**, and get an overview of the activities at **MIT's Media Lab**.

In **Under the Hood**, Brett Glass takes a look at EISA, the newest industry bus standard; in **Some Assembly Required**, Rick Grehan continues his "Two Tin Cans . . ." article on network interfaces with a look at NetBIOS.

As always, our columns, Computing at Chaos Manor, The Unix /bin, Down to Business, Macinations, OS/2 Notebook, and NetWorks, offer **Expert Advice** on a whole raft of problems, from the exotic to the mundane.

Industry news and the latest information on hardware and software are the core of our **Microbytes**, **What's New**, and **Short Takes** sections. These departments, written by BYTE reporters and editors, provide a focus on the important events in microcompting that is unequaled by any other source.

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Index to Advertisers by Product Category

HARDWARE

800 ADD INS

Inquiry No.	Advertiser	Page No.
404	ACER,INC	IS-44,45
521	ADVANCED DIGITAL CORP	NE-3
522	ADVANCED DIGITAL CORP	NE-3
20	ALPHA PRODUCTS	336
27	ATI TECHNOLOGIES	171
31	B & B ELECTRONICS	333
411	BLUE CHIP TECHNOLOGY	IS-56
526	BLUE CIRCLE GROUP,INC	NE-6
527	BLUE CIRCLE GROUP,INC	NE-6
48	B&C MICRO	331
69	CONTROL VISION	341
73	COVOX	334
417	C&D TECHNOLOGY,INC	IS-36
78	DATA TRANSLATION INC	45
92	EDC GMBH	276
105	FTG DATA SYSTEMS	342
425	GAMMA	IS-12
426	GENOA SYSTEMS	IS-4
107	G-TEK, INC.	48D
108	G-TEK, INC.	48D
115	HEATH COMPANY	237
119	HIGH RES. TECHNOLOGIES	328
121	HOME SMART COMPUTERS	328
432	INES	IS-48
435	INTERQUADRAM	IS-9
133	IO COMM	243
134	IO TECH	204
135	IO TECH	331
143	KEA SYSTEMS	341
154	LAWSON LABS	342
167	MAXCIMA	322
440	MICROMINT	IS-34
190	NEC HOME ELECTRONICS	41
192	NOHAU CORPORATION	299
193	NOHAU CORPORATION	333
205	PERISCOPE	144D
206	PERISCOPE	144D
216	PI COMPUTER CORPORATION	322
445	PRICE TREND	IS-6
446	PROCOMP,USA INC.	IS-48
447	PROCOMP,USA INC.	IS-48
208	PSI	323
227	QUA TECH	328
240	RUPP CORPORATION	215
241	RUPP CORPORATION	215
242	RUPP CORPORATION	215
243	RUPP CORPORATION	215
244	RUPP CORPORATION	215
245	RUPP CORPORATION	215
254	SILICON SHACK	338
260	STEINCO A/S	144B
263	STSC	27
495	SUMMA COMPUTER	SO-3
565	TELETEK	NE-11
566	TELETEK	NE-11
511	TELETEK	PC-3
512	TELETEK	PC-3

801 DRIVES

Inquiry No.	Advertiser	Page No.
55	COMPACT DISK PRODUCTS	169
181	MICROTRON TRADE SERVICE	248
*	SEAGATE	203

802 FACSIMILE

Inquiry No.	Advertiser	Page No.
528	COMPFAX	NE-5
529	COMPFAX	NE-5

803 HARDWARE PROGRAMMERS

Inquiry No.	Advertiser	Page No.
32	BARADINE PRODUCTS	334
44	BP MICROSYSTEMS	341
45	BP MICROSYSTEMS	341
47	BYTEK COMPUTER CORP.	337
49	B&C MICRO	331
323	B&C MICRO	333
148	KORE,INC.	331
150	K.E.M. ELECTRONICS	334
155	LINK COMPUTER GRAPHICS	328
157	LOGICAL DEVICES	344
158	LOGICAL DEVICES	344
159	LOGICAL DEVICES	344
160	LOGICAL DEVICES	344
292	XELTEK	333

804 INSTRUMENTATION

Inquiry No.	Advertiser	Page No.
18	ALL REGULATOR AB	333
19	ALL REGULATOR AB	333
93	ELEXOR	341
237	REAL TIME DEVICES	338

805 KEYBOARDS/MICE

Inquiry No.	Advertiser	Page No.
50	CH PRODUCTS	125
51	CH PRODUCTS	125
422	FOCUS ELECTRONIC CO.	IS-57
*	FORTE COMMUNICATIONS	IS-14
428	GTCO	IS-20
429	GTCO	IS-20
172	MEXTEL	256
173	MEXTEL	256
179	MICROSPEED	34
180	MICROSPEED	34
*	NORTHGATE COMPUTER	138,139
194	NUMONICS	210

806 MASS STORAGE

Inquiry No.	Advertiser	Page No.
17	AK SYSTEMS	342
68	CONTECH COMPUTER CORP.	344
504	DATAMAG,INC	PC-2
505	DATAMAG,INC	PC-2
86	DIGI-DATA	342
138	JB TECHNOLOGIES	133
139	JB TECHNOLOGIES	133
174	MICRO SOLUTIONS COMP.PROD	74
181	MICROTRON TRADE SERVICE	248
558	ONLINE PRODUCTS CORP.	NE-17
559	ONLINE PRODUCTS CORP.	NE-17
197	OVERLAND DATA,INC.	321
312	PINNACLE MICRO	258
313	PINNACLE MICRO	258
228	QUALSTAR CORPORATION	342
261	STORAGE DIMENSIONS (N.AMER)	165
262	STORAGE DIMENSIONS (N.AMER)	165
316	STORAGE DIMENSIONS (INT'L)	165
317	STORAGE DIMENSIONS (INT'L)	165

807 MISCELLANEOUS

Inquiry No.	Advertiser	Page No.
33	BAYTECH	186
34	BAYTECH	186
419	DIETRICH	IS-52
99	FOCUS RESEARCH,INC	338
131	INTEGRAND	218
436	INWIN DEVELOPMENT INC	IS-40
171	MERRITT COMPUTER	284
226	QUA TECH	328
*	SCANDEC TRIBUTOR	IS-69
278	TRACE,INC.	109
290	WIESEMANN & THEIS	284
515	WINTIME TECH.	PC-14

808 MODEMS/MULTIPLEXORS

Inquiry No.	Advertiser	Page No.
414	CLEO COMMUNICATIONS	IS-33
57	COMPUCOM	322
322	COMPUTER PERIPHERALS INC	75
277	TOUCHBASE SYSTEMS,INC.	36

809 MONITORS

Inquiry No.	Advertiser	Page No.
404	ACER,INC	IS-44,45
94	ELITE MICROSYSTEMS INC	117
434	INTERQUADRAM	IS-7
189	NEC HOME ELECTRONICS	38,39
201	PANASONIC	175
444	PHILIPS MONITORS	IS-11

810 NETWORK HARDWARE

Inquiry No.	Advertiser	Page No.
469	BRITISH TELECOM	IS-2,3
75	CSS LABORATORIES INC	180
76	CSS LABORATORIES INC	180
*	CUBIX CORPORATION	44
306	DIGIBOARD	296
418	D-LINK SYSTEM,INC	IS-16
112	GOODWAY	144B
549	L&W MICROCOMPUTING	NE-23
550	L&W MICROCOMPUTING	NE-23
175	MICROCOM	219
191	NETWORK TECHNOLOGIES	342
301	SAMSUNG	66,67
302	SAMSUNG	66,67
567	TRANS-M CORP.	NE-13
568	TRANS-M CORP.	NE-13
569	TRANS-M CORP.	NE-13
570	TRANS-M CORP.	NE-13

811 PRINTERS/PLOTTERS

Inquiry No.	Advertiser	Page No.
15	ADVANCED MATRIX TECH	185
*	EPSON	20,21
106	FUJACORP INC	321
116	HEWLETT-PACKARD PERIPH.	14,15
117	HEWLETT-PACKARD PERIPH.	144G
118	HEWLETT-PACKARD PERIPH.	145
122	HOUSTON INSTRUMENT	189
222	QMS	107
223	QMS	107
224	QMS	193
225	QMS	193
483	ZERICON	MW-7
496	ZERICON	SO-8
516	ZERICON	PC-10

812 PRINTERS RIBBONS

Inquiry No.	Advertiser	Page No.
199	PACIFIC DATA PRODUCTS	89
200	PACIFIC DATA PRODUCTS	89
471	WORLD WIDE COPIER PARTS	IS-52

813 SCANNERS/IMAGE PROCESSORS

Inquiry No.	Advertiser	Page No.
161	LOGITECH	54,55
162	LOGITECH	54,55
493	SQUAREFIELD	SO-2
494	SQUAREFIELD	SO-2

814 SOFTWARE SECURITY

Inquiry No.	Advertiser	Page No.
407	ALADDIN KNOWLEDGE SYS.	IS-55
415	CONTROL TELEMETRY	IS-38
421	FAST ELEKTRONIK GMBH	IS-42
156	LOGIC VISION	74
211	PROTECH MARKETING	59
212	PROTECH MARKETING	59
235	RAINBOW TECHNOLOGIES	150
236	RAINBOW TECHNOLOGIES	150
238	ROSE ELECTRONICS	157
239	ROSE ELECTRONICS	157
257	SOFTWARE SECURITY	200

815 SYSTEMS

Inquiry No.	Advertiser	Page No.
403	ABC COMPUTER CO,LTD	IS-61
405	ACME TECHNOLOGY CORP	IS-38
523	ADTECH	NE-31
524	ADTECH	NE-31
13	ADVANCED LOGIC RESEARCH	2,3
14	ADVANCED LOGIC RESEARCH	2,3
409	ADVANTEK INT'L LTD	IS-10
406	AGC ELECTRONICS CORP.	IS-51
*	AMPRO	124
408	AQUARIUS SYSTEMS INC.	IS-39
38	BIT WISE	144C
39	BIT WISE	144C
502	BI-LINK	PC-7
503	CDS	PC-9
318	CLUB AMERICAN TECH	265
67	COMPUTRADE	78
416	COPAM ELECTRONICS CORP	IS-67
71	CORPORATE COMPUTERS OF IOWA	76,77
72	CORPORATE COMPUTERS OF IOWA	76,77
80	DELL COMPUTER	CII,1
*	DELL COMPUTER	64A–B
81	DELL COMPUTER	65
96	ELTECH RESEARCH	271
470	FASTFAME CO.,LTD	IS-40
102	FORTRON	37
103	FORTRON	37
537	FOUNTAIN TECHNOLOGIES	NE-15
538	FUTURA SYSTEMS	NE-4
539	FUTURA SYSTEMS	NE-4
424	GALAXY MICROCRAFT SYS.	IS-52
109	GATEWAY 2000	10,11
303	HAUPPAUGE COMPUTER	285
545	HERTZ	NE-7
120	HITECH EQUIPMENT CORP.	344
430	HWA HSIN ELECTRONIC CO	IS-24
125	H.I.M.S.TECHNOLOGIES	278
*	IBM PS/2	48,48A
437	KAYPRO	IS-37
144	KILA SYSTEMS	331
149	KUSTEM DATA SERVICES	331
170	MEGATEL	88
551	MINTA TECHNOLOGIES	NE-9
22	MITAC	190
*	NORTHGATE COMPUTER	134,135
*	NORTHGATE COMPUTER	136,137
*	NORTHGATE COMPUTER	140,141
491	OCTAGON TECHNOLOGIES	SO-7
492	OCTAGON TECHNOLOGIES	SO-7
556	ON LINE COMPUTER	NE-27
557	ON LINE COMPUTER	NE-27
561	PC PLUS TECHNOLOGIES	NE-19
562	PC PLUS TECHNOLOGIES	NE-19
216	PI COMPUTER CORPORATION	322
445	PRICE TREND	IS-6
234	RADIO SHACK	CIV
563	RENEGADE CORP	NE-35
309	SAELIG COMPANY	334
449	SAMSUNG ELECTRONICS	IS-53
253	SCIOTO COMPUTERS	337
456	SUPERTRON ELECTRIC CO.	IS-41
270	TECHNOLOGY POWER	342
272	TMI,INC.	88
458	TOPLINK COMPUTER CO.	IS-32
273	TOSHIBA	158,159
274	TOSHIBA	158,159
459	TRIANGLE DIGITAL	IS-46
307	TUSSEY COMPUTER PROD.	146,147
308	TUSSEY COMPUTER PROD.	148,149
464	UNIBIT	IS-47
286	WELLS AMERICAN (N.AMER)	153
287	WELLS AMERICAN (N.AMER)	153
320	WELLS AMERICAN (INT'L)	153
321	WELLS AMERICAN (INT'L)	153
288	WELLS AMERICAN	277
289	WELLS AMERICAN	277
400	WINTEK	9
295	ZENITH DATA SYSTEMS	48B
296	ZEOS INTERNATIONAL	90,91
297	ZEOS INTERNATIONAL	92,93
298	ZEOS INTERNATIONAL	94,95
299	ZEOS INTERNATIONAL	96,97

816 TERMINALS

Inquiry No.	Advertiser	Page No.
97	EMERALD COMPUTERS,INC.	35
465	UNITECH COMP.CO,LTD	IS-26

READER SERVICE

Inquiry No. — Page No.

817 UPS

202 PARA SYSTEMS 79

SOFTWARE

818 APPLE/MAC APPLICATIONS Scientific/Technical

70 COREL 238

819 IBM/MSDOS APPLICATIONS Business/Office

412 CLARION SOFTWARE IS-29
413 CLARION SOFTWARE IS-29
60 COMPUTER ASSOCIATES 28,29
132 INTELLIGENCEWARE 71
187 NANTUCKET 199
441 NOVELL IS-25
• ORACLE 57
509 PEOPLESMITH SOFTWARE PC-13
• RAIMA 53
• RAIMA 112
271 THE IDEA WORKS 344

820 IBM/MSDOS APPLICATIONS Scientific/Technical

25 ANNABOOKS 321
35 BE AWARE INC. 86
36 BE AWARE INC. 86
83 DIGITAL RESEARCH 197
84 DIGITAL RESEARCH 197
165 MATHSOFT 51
• MICROSOFT 6,7
188 NATIONAL INSTRUMENT CIII
204 PATTON & PATTON 118
258 SPECTRUM 103
259 STATSOFT 47

821 IBM/MSDOS APPLICATIONS Miscellaneous

123 HYPERKINETIX 110
124 HYPERKINETIX 110
507 KEYBOARD COMEDY PC-11
571 ZEPHYR SERVICES NE-2

822 IBM/MSDOS APPLICATIONS Word Processing

213 FRANKLIN/PROXIMITY 308
214 FRANKLIN/PROXIMITY 308

823 IBM/MSDOS — CAD

23 AMERICAN SMALL BUS.COMP. 114
100 FORESIGHT RESOURCES 23
101 FORESIGHT RESOURCES 23
127 IMAGENET SYSTEMS 331
128 IMAGENET SYSTEMS 331
442 ORCAD SYSTEMS CORP IS-15
508 ORCAD SYSTEMS CORP PC-15
281 ULTIMATE TECHNOLOGY 338
291 WINTEK 337
324 WINTEK 337
400 WINTEK 9

824 IBM/MSDOS COMMUNICATIONS

11 ACS COMMUNICATIONS 344
53 COMMUNICATION RESEARCH GR 274
54 COMMUNICATION RESEARCH GR 274
90 DIVERSIFIED COMPUTER 337
143 KEA SYSTEMS 341
443 PERICOM IS-31
269 TALKING TECHNOLOGY 334
461 TRITON TECHNOLOGIES IS-8
462 TRITON TECHNOLOGIES IS-8

825 IBM/MSDOS — GRAPHICS

79 DAYTRON 344
532 DAYTRON ELECTRONICS NE-22
• ECOSOFT 70
127 IMAGENET SYSTEMS 331
128 IMAGENET SYSTEMS 331
163 MAP INFO 32
315 PINNACLE PUBLISHING 302
250 SCIENTIFIC ENDEAVORS 338
251 SCIENTIFIC ENDEAVORS 338
252 SCIENTIFIC ENDEAVORS 338

826 IBM/MSDOS — LAN

533 DRAGONSLAYER SYSTEMS NE-33
• ELONEX IS-19
453 SOFTTEK COMPUTER IS-56
564 SUMMA COMPUTER NE-34

827 IBM/MSDOS — LANGUAGES

10 2500 AD SOFTWARE 144
42 BORLAND INTERNATIONAL 13
43 BORLAND INTERNATIONAL 13
85 DIGITALK 24,25
95 ELLIS COMPUTING 133
• JENSEN & PARTNERS 127
151 LAHEY COMPUTER SYS. 144F
• MICROSOFT 19
184 MIX SOFTWARE 305
454 STONY BROOK SOFTWARE IS-27
455 STONY BROOK SOFTWARE IS-27
285 WATCOM 120
300 ZORTECH 233

828 IBM/MSDOS — UTILITIES

29 ATTACHMATE CORP. 154
41 BLAISE COMPUTING 48C
28 CADRE TECHNOLOGIES INC 31
468 COBALT BLUE IS-46
79 DAYTRON 344
113 HAMMERLY COMPUTER SERV. 272
114 HAMMERLY COMPUTER SERV. 273
431 I X I LTD. IS-56
129 IMES GMBH 338
152 LANTANA TECHNOLOGY 298
153 LANTANA TECHNOLOGY 298
310 LOGITECH 46
311 LOGITECH 46
178 MICROSOFT 85
184 MIX SOFTWARE 305
185 MKS 123
195 NU-MEGA TECHNOLOGIES 121
203 PARSONS TECHNOLOGY 87
509 PEOPLESMITH SOFTWARE PC-13
319 PETER NORTON 255
207 PHAR LAP 198
230 QUARTERDECK 128,129
231 QUARTERDECK 128,129
232 QUARTERDECK 128,129
233 QUARTERDECK 128,129
452 SOFTWARE CONSTRUCTION IS-43
264 SUPERSOFT 80
266 SWIRLSOFT 341
279 TRAVELING SOFTWARE 105
• VERMONT CREATIVE 16

829 OTHER APPLICATIONS Business/Office

74 CRICHLOW 328
87 DOCUBASE SYSTEMS 206

830 OTHER APPLICATIONS Scientific/Technical

30 A/SOFT DEVELOPMENT,INC. 132
37 BINARY TECHNOLOGY 338

831 OTHER — CROSS DEVELOPMENT

• SOFTWARE DEVELOPMENT SYS 83

832 OTHER — LANGUAGES

104 FRANKLIN SOFTWARE 86
294 Z-WORLD 334

833 DESKTOP PUBLISHING

166 MATRIX 207

834 EDUCATIONAL/ INSTRUCTIONAL

410 BIX IS-71
• BYTE BACK ISSUES 326
• BYTE BACK ISSUES IS-68
46 BYTE BITS 331
• BYTE PUBLICATIONS 72,73
• BYTE PUBLICATIONS IS-70
• BYTE PUBLICATIONS IS-72
• BYTE SUB MESSAGE 42
• BYTEWEEK/NEWSLETTER 363
• BYTEWEEK/NEWSLETTER MW-2
• BYTEWEEK/NEWSLETTER PC-4
• BYTEWEEK/NEWSLETTER SO-4
55 COMPACT DISK PRODUCTS 169
• COMPUTER PROFESSIONAL 112A-B
268 COMPUTER PROFESSIONALS BK113
• COMP.FOR THE BLIND MW-4
• DATA COMMUNICATIONS IS-49
• DATA COMMUNICATIONS MW-8
• DATA COMMUNICATIONS NE-24
• DATA COMMUNICATIONS PC-16
• DATA COMMUNICATIONS SO-12
• DATA COMMUNICATIONS IS-48A-B
506 HEALD INSTITUTE OF TECH PC-13
145 KNOWLEDGE GARDEN 361
• SMALL COMP BOOK CLUB 32A-B
• SMALL COMP BOOK CLUB 33
• UNIXWORLD 329

835 MAIL ORDER/ RETAIL

401 06 SOFTWARE CENTRE EUROPE IS-58
402 06 SOFTWARE CENTRE EUROPE IS-59
499 3-F ASSOCIATES PC-8
16 ADVANTAGE SOFTWARE 119
21 AMERICAL GROUP 328
486 A-TRONIC COMPUTER SO-11
525 A-TRONIC COMPUTER NE-21
• CALIFORNIA DIGITAL 345
52 CLONE COMPUTER 327
56 COMPUCLASSICS 142
305 COMPUTER DIRECT 294,295
61 COMPUTER DISC.WAREHOUSE 144
530 COMPUTER EXPERT,INC NE-32
531 COMPUTER EXPERT,INC NE-32
62 COMPUTER FRIENDS 144H
63 COMPUTER MAIL ORDER 176,177
64 COMPUTER MAIL ORDER 178,179
65 COMPUTER MAIL ORDER 208,209
487 COMPUTER WHOLESALERS SO-5
488 COMPUTER WHOLESALERS SO-5
66 COMPUTERLANE 330
476 DAKOTA COMPUTER MW-3
• DAMARK 247
82 DELTA COMPUTING TECH. 342
88 DISKCOTECH 341
89 DISKETTE CONNECTION 337
91 DYNAMIC ELECTRONICS 321
534 EDI NE-20
535 EDI NE-20
536 ELECTRIFIED DISCOUNTERS NE-25
304 ELS ENTERPRISES,LTD 286
98 EXECUTIVE PHOTO & SUPPLY 194
314 EXSEL 357
427 GREY MATTER IS-65
26 G.REED,INC. 328
477 HALSKAR SYSTEMS MW-6
478 HALSKAR SYSTEMS MW-6
540 HALSKAR SYSTEMS NE-8
541 HALSKAR SYSTEMS NE-8
542 HARMONY COMPUTERS NE-1
543 HARMONY COMPUTERS NE-1
544 HARVARD INFO SYSTEMS NE-6
546 HY-TEC NE-12
547 HY-TEC NE-12
126 IC EXPRESS 337
130 INMAC 246
136 JADE COMPUTER PRODUCTS 339
137 JAMECO 324,325
140 J.D.R. MICRODEVICES 346,347
141 J.D.R. MICRODEVICES 348,349
548 LAPTOPS ETC. NE-28
164 MARYMAC 334
438 MAYFAIR MICROS IS-63
169 MEAD COMPUTER 332
• MICROCOMPUTER MKTG CNCL 343
176 MICROPROCESSORS UNLTD 328
• MICROWAY 173
182 MICROWAY 275
489 MIGHTY MICRO SO-1
490 MIGHTY MICRO SO-1
• MONTGOMERY GRANT 130
552 MPM NE-36
553 MPM NE-36
554 M.S.C. NE-29
186 NAGAN CORP. 344
479 NEXT WORKS, THE MW-1
480 NEXT WORKS, THE MW-1
555 NOCONA ELECTRONICS NE-22
196 ON LINE STORE 335
198 PACIFIC COMPUTERS 323
560 PC LINK NE-16
209 PRIORITY ONE COMPUTER 230
210 PROGRAMMER'S PARADISE 60,61
217 P.C. NETWORK 43
218 P.C.BRAND 221
219 P.C.BRAND 222,223
220 P.C.BRAND 224,225
221 P.C.BRAND 226,227
448 QUOTHA 32 IS-46
249 SCHWAB COMPUTER 333
451 SCOTTSDALE SYSTEMS IS-13
• SOFTLINE CORPORATION IS-35
510 SOFTWARE ENGINEERING PC-12
265 SURAH, INC. 344
267 S'NW COMPUTER 214
513 TRAN COMPUTER NETWORK PC-1
514 TRAN COMPUTER NETWORK PC-1
280 T.P.C. 326
282 UNITEX 340
466 USA SOFTWARE IS-23
284 WAREHOUSE DATA 205
481 Y.E.S.SYSTEMS CORP. MW-5
482 Y.E.S.SYSTEMS CORP. MW-5

836 MISCELLANEOUS

• ANTHRO 42
246 SAFEWARE 341
463 TWINHEAD INT'L CORP. IS-50

837 ON-LINE SERVICES

450 BIX 358,359
59 COMPUSERVE 257
110 GE INFO SERVICES 216

838 OPERATING SYSTEMS

8 2001 SALES 220
9 2001 SALES 220
• IBM OS/2 167
142 KADAK 342
229 QUANTUM SOFTWARE 69
248 SANTA CRUZ OPERATION 63
255 SOFTWARE LINK 213
256 SOFTWARE LINK 213
453 SOFTTEK COMPUTER IS-56
263 STSC 27

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OCTOBER 1989

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	68	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	138	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	238	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380
381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	468	489	490	491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560
561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580
581	582	583	584	585	586	587	568	589	590	591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620
621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	840
641	642	643	644	645	646	647	648	649	650	651	652	653	654	855	656	857	658	659	660
661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680
681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720
721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740
741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760
761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780
781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	630	831	832	833	834	835	836	837	838	839	840
841	842	643	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860
861	862	863	864	865	888	867	868	869	870	871	872	873	874	875	876	877	878	879	880
881	882	683	884	885	686	887	688	689	890	891	892	893	894	895	896	897	898	899	900
901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920
921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940
941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960
961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980
981	982	983	984	985	986	987	968	989	990	991	992	993	994	995	996	997	998	999	1000
1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020
1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040
1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060
1061	1062	1063	1064	1085	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080
1081	1082	1083	1084	1085	1066	1087	1068	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100
1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120
1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140
1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160
1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180
1181	1182	1183	1184	1185	1186	1187	1168	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200

continued from page 308
requester and responder delete their names from the network by calling RemoveName, and the responder releases the socket used for servicing requests by calling CloseATPSocket.

The requester had actually opened two sockets, one to pass to RegisterName and another with which to carry out a transaction during the SendRequest call. The program doesn't explicitly open the second socket; ATP does that automatically in SendRequest. When the request arrives at the responder's end, the GetRequest function passes a "return address" to the responder's application program, so it knows where to send the response packet. The requester never really knows, nor needs to know, its own socket number.

Now You're Talking

Communicating with AppleTalk is more or less a matter of filling entries in a parameter block (a block of memory of predefined fields), loading register A0 with a pointer to the parameter block, and calling the proper function. A general road map of the parameter block would be difficult to construct, since it changes depending on whether you're calling NBP or ATP. Your best bet is to keep a copy of *Inside Macintosh* on hand. The pseudocode in listing 1 indicates those locations where the program is filling the fields of the parameter block with an IN Parameterblock DO structure (vaguely similar to Pascal's WITH construct). I have tried to keep the field names as close to the mnemonics given in *Inside AppleTalk* as possible.

The pseudocode follows the process I outlined above. Each side (sender and receiver) opens a socket, registers a name on the network, and then performs a LookupName() to locate the other side. The program branches to one of two processes, depending on whether it's sending or receiving.

The sender begins reading the file, transmitting 512-byte blocks via SendRequest(). The receiver reads the requests with GetRequest(), writes the data to the destination file, and then acknowledges its receipt with a SendResponse(). (Note that there's no real content to the response; it serves as an acknowledgment signal.) When the last block is transmitted (signaled by a block smaller than 512 bytes), both sides close their files and remove their names from the name table.

There are two data structures of special note that are too complex to describe in the pseudocode. The first is the buffer data structure (BDS). Before a program can send a request, it has to get its house in order for the response(s) it's certain to receive. (Remember that a given request can trigger up to eight responses.) ATP's SendRequest routine requires that you construct a BDS describing where incoming responses are routed.

Each element of a BDS—there can be up to eight—contains a pointer to available memory for the associated response, a byte count telling how big that memory is, and another byte count for how many bytes were actually received (see figure 2). When the first response comes in, it looks in BDS element 0 to figure out where to put the response data. When the second response comes in, it looks in BDS element 1, and so on. Since my program expects only one response consisting of a doubleword, this requires a single BDS element pointing to a 4-byte buffer.

The second data structure is used exclusively by NBP and is described in figure 3. The names table entry (NTE) is a member of a linked list that NBP keeps in memory. Each member corresponds to a name on the network associated with your node. NBP knows what names go with what network number, node, and socket. Whenever you register a name, you have to set aside memory space for that name's NTE. Furthermore, the NTE's memory block must be locked as long as that name is active (or it could get lost if memory moves during a heap compaction).

Done Talking

This concludes my romp through AppleTalk. Next month, I'll do the same for NetBIOS. The source code for this month's program is available via the usual routes under filename ATTRANS (see page 5 for details). It's written in Palo Alto's Mach 2 Forth but should be readily adaptable to any other Forth dialect (and, with the help of the pseudocode, to other languages).

I plan to take a look at AppleTalk's Extended Protocol Package (XPP) in this column sometime in the near future. Stay tuned. ■

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Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

BIX CALENDAR

OCTOBER

Display this month's BIX activities

O C T R

Let the interactive games begin!

BIX's newest exchange, the *Interactive Game Exchange,* is dedicated to interactive recreation on line. Action continues every night, and you can access it via your computer and BIX. Just as you can access all the other BIX exchanges—*Bulletin, IBM, Macintosh,* and *User's Group*—and all the BIX conferences.

SUNDAYS, 9 PM EST. Poetic Liberties

Poetry, art, music and stories from by gone days to yet-to-come days are featured in this conference. (join fun.n.games/game.room)

SUNDAYS, 9:30 PM EST. School Night

Learn about role-playing games on line and off line at Fantasy Foundation College. (join ff/ff.col)

MONDAYS, 9 PM–Midnight EST. Check into the Meade & Mirth Inn

A free-form game set in the Middle Ages or far into the future. (join mnm/inn)

TUESDAYS & WEDNESDAYS, 9:30 PM EST. As the Ledinworld Turns

Ledinworld is the advanced D&D center of the Exchange. Enjoy real-time fantasy role-playing games as well as message-based player interaction. (join lworld/ledinworld)

THURSDAYS, 9 PM EST. Meanwhile, Back at the Inn . . .

. . . the free-form, role-playing games continue as the mead and mirth flow. (join mnm/inn)

THURSDAYS, 10:15 PM EST. Pandemonium

Contemporary parlor games and social activities. (join fun.n.games/game.room)

FRIDAYS, 9 PM EST. Trivia . . .

Begin your T.G.I.F. nights in the pursuit of trivia. (join fun.n.games/game.room)

FRIDAYS, 9:30 PM EST. . . . & Other Pursuits

. . . such as *"Argonauts,"* the futuristic role-playing game. (join encounters/new.worlds)

SATURDAYS, 8:30 PM EST. Fantasy Meeting You Here

Play *"One Night In Waterdeep"* and other real-time fantasy role-playing games. (join lworld/ledinworld)

SATURDAYS, 9 PM EST. More Meade & Mirth

And you can add to the mirth every Saturday night. (join mnm/inn)

All-Month Conferences and Special Events

Macintosh Exchange—We expand BYTE's optical-devices product focus and in-depth coverage in the Macintosh Exchange this month by looking at some of the available optical-storage devices for the Mac. With rewritable optical media routinely able to store 600 megabytes, what can the Mac user expect to use such devices for? (join mac.hack)

Blue Tuesdays—Every Tuesday in October (9PM EST), join Barry Nance, IBM Exchange Editor, and the IBM conference moderators as they discuss issues and answer your questions about IBM and workalike computers. (join the main CBix area, channel 1, band B)

Wizards of OS.9—You're off to meet the wizards in this special focus on CD-I/CD-RTOS with guest experts. (join os.9)

New Conferences

journalism—Let practicing journalists show you how, what, when, where and why. (join journalism)

journalism.pro—A closed conference for professional journalists. Contact 'janziff' or 'jonhall' for details on how to join this conference.

sfwa—A closed conference for members of the *Science Fiction Writers of America*. Contact 'mike__banks' for details.

mac.macappda—Join with members of the *Macintosh Applications Developers Association* as they create new software for the Macintosh series. (join mac.macappda)

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Hugh Kenner

Curtains for Lady Buxley

THE HUMANITIES COMPUTING YEARBOOK: 1988

edited by Ian Lancashire and Willard McCarty

The Macintosh requests a decision. You are Denis Marin, born 1638, and in the French society of that era, your aim is (what else?) to maximize family prestige. Economic, political, marital opportunities abound. A flow of correspondence has kept you informed. You want a wife who will bring fortune and connections. Propose to Mlle. X? Ah, best check her status. If yours is lower, a refusal would ghettoize you for years. Such were seventeenth-century French realities.

In fact, you are an undergraduate studying the ancien régime. You are running a program called The Would-Be Gentleman, which lets you guide the Marin family through two generations, to 1715. A sort of pedagogical Zork, it calls for some 154 decisions (buy? sell? marry? beget?), and "when students act from twentieth-century motivations rather than from seventeenth-century assumptions, they fall neatly into traps set for them. A common way of losing the game is to arrive at 1715 with loads of cash and a high status but without any children to inherit them." That's no way to set up a dynasty.

This program, available for a mere $7, engages students in "historical concepts otherwise very difficult to teach"; they learn, interactively, what it was like to live at that level of ambition in those years. It's described on page 150 of *The Humanities Computing Yearbook*, a work indispensable for anyone engaged in the field. (A *huge* field; in a moment, I'll try to describe it.) This first volume attempts a comprehensive survey from earliest times (the 1960s) through 1988. Hereafter, annual updates are promised.

All right, the "field": nearly anything that turns on "our writing system, the printing press, the public library," also art history, biblical studies, creative writing, editing and publishing, history, languages and literatures, text analysis...on and on. It's easier to say what's not included: no business applications, no engineering ones. To this broad domain, some 400 pages of fairly small print now offer a well-organized annotated bibliography, plus lists (with sources) of available software.

There are many surprises. Two decades ago, David Packard, a classicist who happens to be a Hewlett-Packard Packard, was reflecting that much of classical scholarship has always amounted to numb pattern-matching. (Find, in the corpus of Greek literature, every instance of the word *oinope*. Bleary-eyed insomniacs, century after century, fingered parchment to accomplish chores like that.)

Packard's ruminations (I'm simplifying) led to section 19.7.1, "The A.P.A. Corpus: a repository of Greek and Latin texts in machine-readable form," developed by the Packard Humanities Institute and described in *Classical Journal* as long ago as 1977. (A.P.A. is the American Philological Association.) Since "Greek and Latin literature" can be rather strictly defined, it's possible to claim that the "Corpus" is virtually complete. So the humanities discipline long deemed the very stuffiest got computerized ahead of all the rest.

No trick now to turn up all those instances of *oinope*. Homer applied it 10 times to the sea—hence the familiar translation, "wine-dark." But he also used it once for oxen, and Sophocles used it for a human forearm. A wine-dark arm? Perhaps we'd best rethink. Oxen sweat; so do arms. The sea too flashes back light from its fluent surface. May that word point not to color but—ah—to gleam?

The work with *oinope* was long since done, by hand. It's also had to be checked by repeated redoing; human eyes wander, human memories leak. So, post-Packard, we find machines dedrudging processes centuries-long defined. To deduce what old words may connote requires collections of instances to scrutinize. No better collector than a PDP-11.

continued

Technology doing what was long done by hand: That's the story in field after field. Databases, unsurprisingly, are everywhere. Art historians use them, lexicographers, philologists. There's even one of Texas cave paintings, with digitized images. Archaeology, keeping track of countless sites and objects (e.g., pots, bones, and buttons), enjoys not only relational databases but a shareware program to analyze them.

At this moment, some humanities computing seems to be in a state of free-fall. It's tool-driven, a bad way to be. Better, be situation-driven.

And some things now get done that our parents could never have thought of. When NASA's land-mapping techniques for digital image processing were turned on the *Mona Lisa*, they spotted areas where it had been altered.

Amid literary studies, though, things can get murky. No denying it, some things there are stably quantifiable. Think of letter- and word-frequency distributions. And there are writers whose manner we soon learn to recognize at a glance; Henry James comes to mind. So what it is that we're recognizing: might *that* be described by statistics? It's long been a tempting thought, and now we have computers. . . .

Computerized procedures, I'm serenely convinced, could well distinguish the prose of James from that of Mickey Spillane. I'm less certain that they could sort out—oh, three George Bush speechwriters; there, surely, the style of the genre swamps nuances of personality? Yet that's the kind of question some historian may one day be asking.

So we find section 25.1, "Authorship Analysis," a controversial procedure indeed that looks for a writer's "fingerprint" by number-crunching measures of vocabulary and syntax and then offers decisions about texts of unknown authorship. One problem area is the sheer impossibility of verifying its findings. Trajectory calculations we can verify by firing a bullet. Unknown authorship, by whatever means we guess, must remain, alas, unknown.

The procedure is amusingly spun off in section 12.2, "Tools for Composition," where an outfit called Glatt Plagiarism Services helps instructors put "the suspected student" into the hot seat while a paper gets fingerprinted for plagiarism.

You want to know how that's done? Well, it assumes (1) the uniqueness of your "fingerprint," and (2) no one's ability to emulate a fingerprint as well as its owner. You're presented with your paper, every fifth word blanked out. You're timed while you sweat at filling in the blanks. The result goes off to Glatt, where they combine time with total correct responses to estimate a PPS (plagiarism probability score). For this, the instructor pays $500 annually. A longtime instructor, I'm willing to trust hunches.

Or, if you've heard about text generators, over in section 7.3 there's Automatic Novel Writer, to generate 2100-word murder stories (which seem long enough) beginning, for example, "Wonderful smart Lady Buxley was rich. Ugly oversexed Lady Buxley was single." Or (7.4) Returner, "A program that analyzes Alberta T. Turner's poem 'Return' and simulates stanzas of a like kind." Spare me. One "Return" is enough.

Alberta T. Turner aside, I'm persuaded that interesting texts can be somehow spun out of existing texts. Charles Hartman and I have a book of poems in press; it fascinates us that you'd never guess what the computer derived them from (sentences for schoolchildren to analyze and parse). Somehow, a human core lingers. What constitutes it is a mystery. And the feel of our output differs from what's spawned by word lists plugged into sentence patterns. There's a great deal to be learned hereabouts.

Yes, some of this research seems trivial. Trivial too, if you had them all spread out before you, might be many of the findings of computer science. We're still learning what best to ask of our wondrously literal-minded slave. When a keystroke will give you a count of the letter *q* in a text, well, you're apt to request it, never mind what to think next. At this moment, some humanities computing seems in a state of free-fall. It's tool-driven, a bad way to be. Better, be situation-driven, the way the following narrative illustrates.

Fifty-some years ago, it occurred to Miles Hanley at the University of Wisconsin that James Joyce's *Ulysses* was one book for which a word index would be uniquely valuable, so deliberate had been Joyce's employment of isolate words. (He crossed them off long lists.) But, in 1936, a word index to a quarter-million-word text? Improbably, it got done, with cards and student slave labor and minuscule grants, and was circulated by mimeograph. And it made intellectual history, still not wholly reckoned, when its statistical tables—a seeming afterthought—caught the eye of a fanatic, Harvard's George Kingsley Zipf.

Zipf noted what has since been known as Zipf's law: an exact inverse correlation between frequency and appearance. There had been no statistics for a text of this size before. And lo, if the commonest word (*the*) occurred 16,000 times, then—as if to compensate—the count of *Ulysses* words that occurred but once was 16,000! And so on. A log-to-log graph of frequency versus occurrence is a straight slanting line. It gets pondered yet. Trying to lend it mathematical rigor was the effort of Benoit Mandelbrot's first published paper, and chapter 38 of *The Fractal Geometry of Nature* shows that line of thought pointing him toward what he's famous for.

The moral seems to be that Hanley knew what he wanted, an index to a unique text, and Zipf knew what he wanted, a pattern, and Mandelbrot knew what he wanted, a taxonomy of patterns. The tool-driven often don't quite know what they want, and they generate Automatic Writers of "novels" that no one is likely to dream of reading. I promise not to report another sentence about ugly oversexed Lady Buxley. ■

Oxford University Press, New York: 1988, 404 pages, $59

Hugh Kenner is a professor of English at Johns Hopkins University. His reviews have appeared in publications like the New York Times *and* Harper's. *His recent books include* A Sinking Island *and* Mazes. *He can be contacted on BIX as "hkenner."*

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GOODBYE, MR. CHIPS

The computer revolution is a success, and nothing will ever be the same

When I was in seventh grade in 1976, my friends and I discovered the phone number to access the nation's research network, ARPANET. We found an unattended teletype with a modem in a science lab of our forward-thinking junior high school and dialed away. ARPANET asked for a password, but we soon discovered that it didn't matter what we typed—the network would always let us in. Back then, life was free and easy in the world of computers, and nobody worried about security.

My friends and I spent the rest of the school year playing computer games, talking to people at MIT, experimenting with the software, and trying to find our way around a toy that was as big as all of the U.S. We never did anything damaging, and no one seemed to worry or even care that we were there.

In an earlier frontier—the American west—there was a sheriff, but he had plenty of ground to cover. The peace was kept by an unofficial code of what was good and bad. And just as the old gunfighter never shot anyone in the back, a hacker would never erase someone else's files. He or she might hide them or play some other clever prank that made him or her the most awesome weenie around, but the actions were never fatal. It was a wild West with a sense of humor, a Sergio Leone movie with Robin Williams instead of Clint Eastwood.

Now, though, the frontiers are closing in. As time goes by, there will be fewer and fewer leisurely raft trips through the electronic rivers for the Huck Finns among us who would rather avoid being civilized. Computer shenanigans are big news, and the people judging the mug shot in the paper are rarely going to relish the technical bravado. They are more likely to have a chip on the shoulder from the last time a computer screwed up one of their bills.

In the old days, the computer weenie caught slipping into forbidden machines was rarely dealt with in court. Although the crime was usually the equivalent of breaking and entering, the laws were vague and generally predated the transistor. The victims usually settled with the hacker out of court, in return for learning about the security holes in the system. Now, several years after the movie "War Games" hit the screens, prosecutors see electronic cat burglars as an interesting evolving part of the law—but not a technical problem beyond understanding.

In Syracuse, the story of Robert Morris, America's computing cover boy, continues to unwind. Morris is charged with creating the virus that brought ARPANET to its knees last November. The federal government will attempt to prosecute Morris under a 1986 law prohibiting unauthorized use of federal computers. This is an important case to the government; it doesn't want the case to end in an acquittal, thereby sending the wrong message to all the budding young computer geniuses out there.

Getting a conviction in this case will be difficult. The prosecution will have to deal successfully with the philosophical question of whether a person who programs a virus to invade a computer is guilty of invading the computer. And what constitutes evidence that the mastermind did it all? There is also the problem of intent; the law prohibits destroying or copying information, but the virus that crippled ARPANET was only out for a Sunday drive, albeit at light speed.

When the automobile was introduced, those who could afford to buy one were overcome by an incredible feeling of liberation. The automobile gave people the freedom to go anywhere. Henry Ford wasn't a great success because he built a clever assembly line, but because he turned the dream of being able to hop to the next town on a whim into reality. Unfortunately, too much of this four-wheeled freedom has come to mean smog, traffic jams, auto insurance, speed limits, and long lines at the Department of Transportation. Is California still known for being the untamed land at the end of the frontier? No; it's now just the home of the freeway.

Will the same thing happen with computers? I'm afraid so. It will take a while, but the power of civilization is too strong to resist. The computer revolution is threatened with the curse of succeeding. Once everyone starts using some new machine, the temptation to make everything right by regulation comes creeping in. One minute you're on the cutting edge of technology, and the next minute, there's a large, gray building in Washington overseeing your actions.

There really is no other way. When things get big and everyone gets involved, keeping the peace must be made more efficient. I guess that's what computer scientists would want if we were organizing the world the way they try to organize their software: justice completely and rigorously defined.

But somehow, it doesn't seem the same anymore. ■

Peter Wayner, a consulting editor for BYTE and a graduate student at Cornell University, recently completed a summer internship at Xerox Palo Alto Research Center. He can be reached on BIX as "pwayner."

Stop Bit is an open forum for informed opinion on topics related to personal computing. The opinions expressed are those of the author and not necessarily those of BYTE or its staff. Your contributions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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