BYTE

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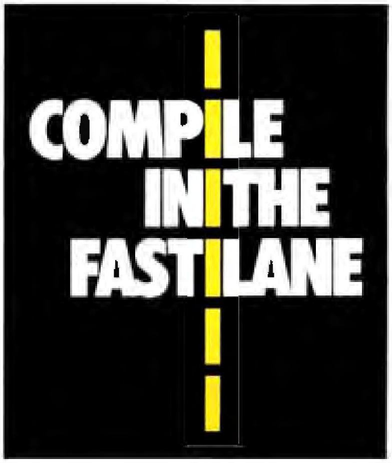

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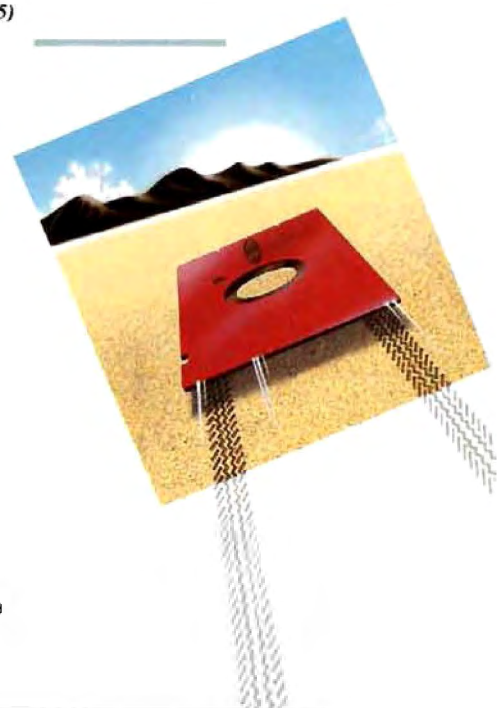

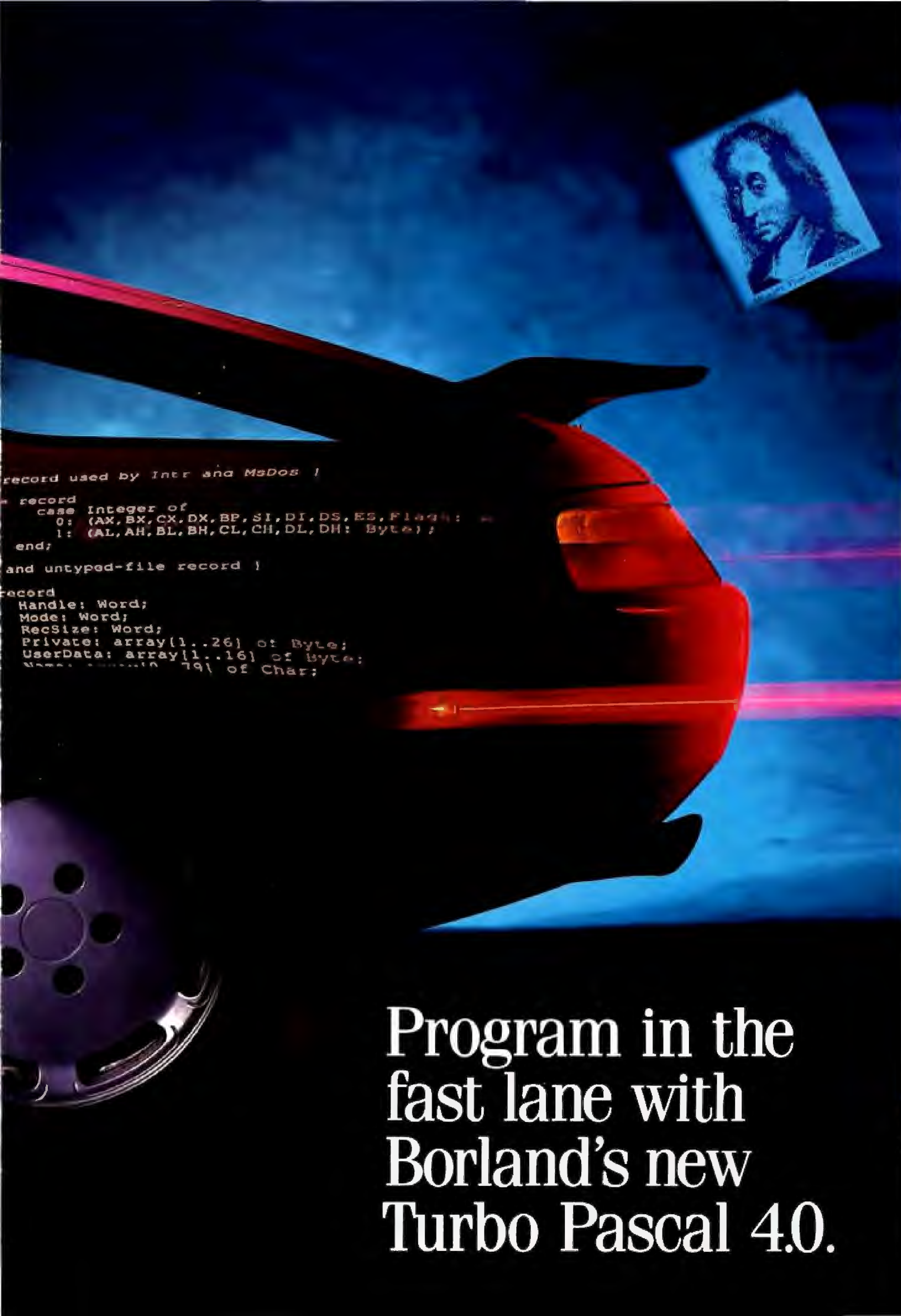

record used by Intr and MsDos }
record
case Integer of
0: (AX,BX,CX,DX,BP,SI,DI,DS,ES,Flags:
1: (AL,AH,BL,BH,CL,CH,DL,DH: Byte);
end;
and untyped-file record }
record
Handle: Word;
Mode: Word;
RecSize: Word;
Private: array[1..26] of Byte;
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Sieve (25 iterations)

	Turbo Pascal 4.0	**Turbo Pascal 3.0**
Size of Executable File	2224 bytes	11682 bytes
Execution speed	9.3 seconds	9.7 seconds

Sieve of Eratosthenes, run on an 8MHz IBM AT

Since the source file above is too small to indicate a difference in compilation speed we compiled our GOMOKU program from Turbo Gameworks to give you a true sense of how much faster 4.0 really is!

Compilation of GO.PAS (1006 lines)

	Turbo Pascal 4.0	**Turbo Pascal 3.0**
Compilation speed	2.2 seconds	3.6 seconds
Lines per minute	27,436	16,750

GO.PAS compiled on an 8 MHz IBM AT

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EDITORIAL

News and Technology

There's something different in BYTE this month. It's a change that appears small, but—like the tip of the proverbial iceberg—represents something far larger.

This month, our Microbytes section is 33 percent larger. That's the "small" part. But it represents a larger internal change here at BYTE: we've created a brand-new "News and Technology" department headed by Rich Malloy, our senior technical editor in New York.

This new department is the first visible sign of many operational changes we have under way here at BYTE: we've literally outgrown the internal structures that served so well for BYTE's first decade. Now, starting with the department that is BYTE's eyes and ears in the microcomputer industry, we're taking a critical look at the way we operate—all for the purpose of making BYTE more responsive, flexible, timely, and just plain *better* than ever.

Here's what Rich has to say about BYTE's new news department:

"The What's New and Microbytes sections of BYTE have consistently been two of the most popular parts of the magazine, and deservedly so. What's New presents the vital facts about new significant hardware and software. Microbytes, on the other hand, provides important information about new technology. In both cases, we don't waste your time: everything's presented in a short and easy-to-read format. And—unlike what you find all too often in the me-too microcomputer news publications—we never merely repackage press releases. We present only the most significant and factual material, frequently the result of unduplicated original reporting and research."

Microbytes

Dennis Barker, who coordinates the Microbytes section of the news operation, agrees:

"In Microbytes, we talk about research and developments that will eventually change the way you use your computer, change the way your computer works. We write about innovative uses of personal computers, regardless of brand name. Some stories are based on information from the R&D departments of the leaders of the microcomputing industry, but others derive from the less-splashy but no less important work done in some plain little room somewhere by someone you have probably never heard of: No matter what the source, if their work is likely to alter the way you use your computer, we'll cover it. You won't find stories like these in other computer magazines.

"Or anywhere—except in the on-line version of Microbytes on BIX. Each weekday we run new stories on computer technology and the computer industry. We cover R&D, industry seminars and events, and new and forthcoming products. We also provide daily live coverage of big shows like COMDEX, where we unleash a whole pack of reporters and editors on the show floor.

"BIX users can send us messages online asking for information about the show, about what's been announced, about a certain new product, about what a certain company is doing, and we do our best to track down answers for them. The electronic media lets us be timely as well as interactive. Our on-line readers can zap us a message right after reading a story. And we get right back to them. Have you ever tried getting in touch with a particular reporter at a newspaper? I don't think too many publications offer such lines of communication."

Short Takes, and More

The new News and Technology department is also responsible for our Short Takes section, where we present concise, hands-on evaluations of brand new products—so new, in fact, they often haven't officially been released for sale. All our Short Takes are staff-written, so you can be assured of the quality and objectivity of the information we present there. Anne Lent has been doing an excellent job putting this section together. We will be constantly fine-tuning and improving it in the future.

Of course, making improvements on a quality product is rarely easy, whether you are talking about Short Takes, or the entire News and Technology department. But here's what Rich Malloy has in mind:

"We want to make our information as accessible as possible: Imagine the high-quality What's New section, but with more photographs and technical graphics. Now imagine a phone service that you can call to receive the latest computer industry news, even if you are miles away from your computer. Heard a rumor about a new '386 machine? One simple phone call and you'll find out for sure. And now imagine a Hypertext-style roundup of all of the news for a particular period of time. Sound interesting? Stay tuned."

First, and Best

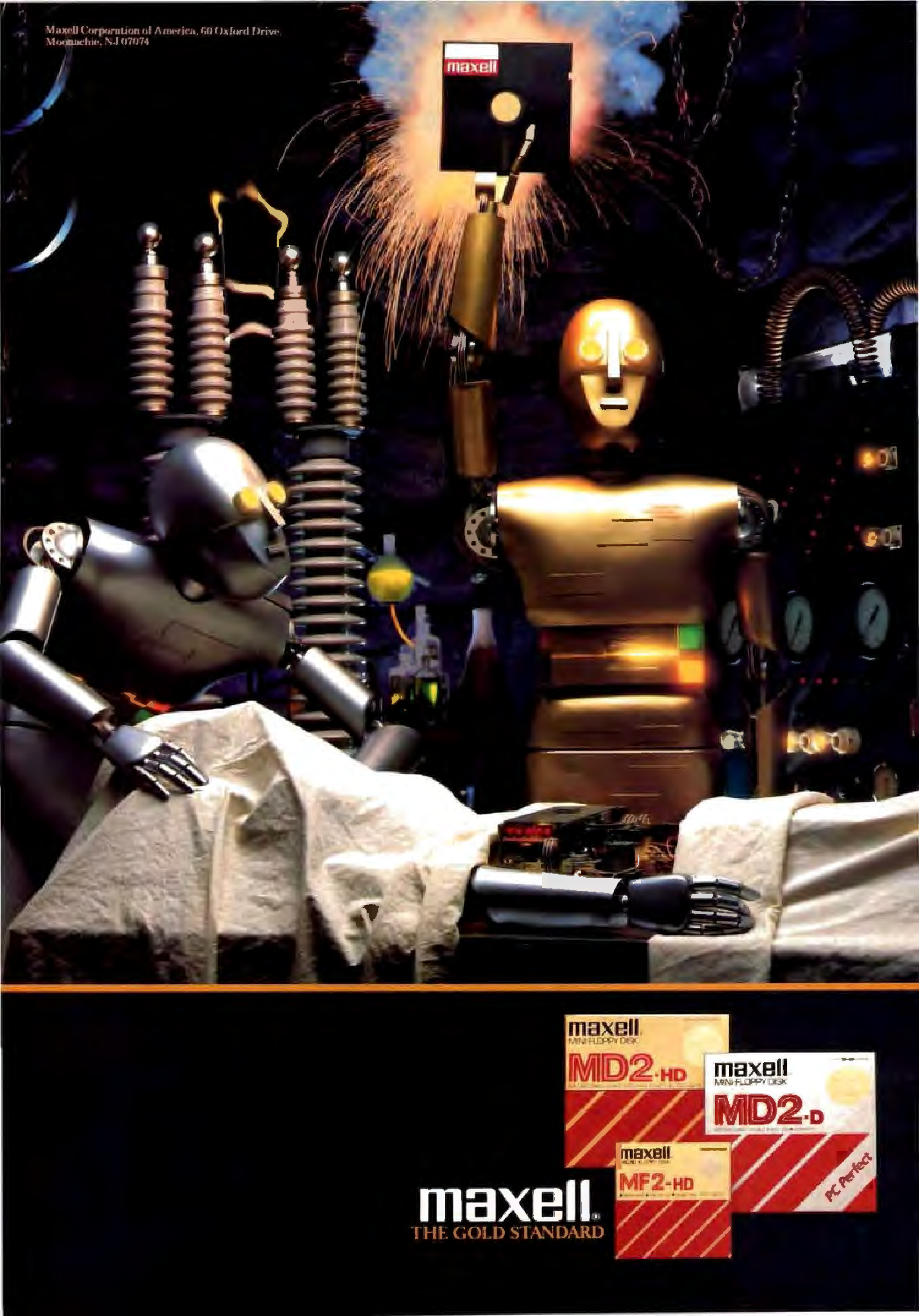
Actually, none of this should be surprising. You and I and the BYTE staff are—in one form or another—involved in the most exciting industry in the world, perhaps the most exciting industry of all time. And not only is there a tremendous amount of news being developed, but a number of new channels of distributing that news are also being developed. It's only fitting that the most prestigious publication covering this industry should have the best and most up-to-date news coverage available: Bear in mind that BYTE has an unsurpassed track record of innovation, from being the first real magazine to devote itself solely to small computers, to becoming the first and, thus far, only magazine to have its own computer conferencing service. Our history of firsts is a pointer to innovation in the future.

If you have news—product and technology developments, or any information you think other computer users would want to know about—give us a call. (It's no problem if you need to speak confidentially.)

You can reach Rich Malloy (News and Technology) in New York at (212) 512-3175. Dennis Barker (Microbytes), Anne Lent (What's New and Short Takes) and I are available in New Hampshire at (603) 924-9281. Or, if it's more convenient, you can call our West Coast offices in San Francisco at (415) 954-9718 or in Costa Mesa at (714) 557-6292. The full mailing addresses for all our branches appear on page 4. All our staff is also available through BIX.

In the computer business as in any business, constant innovation and attention to quality are part of the foundation for success. That's the way we feel, and that's what we will provide. But what's more important is how *you* feel. As always, we welcome hearing from you.

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



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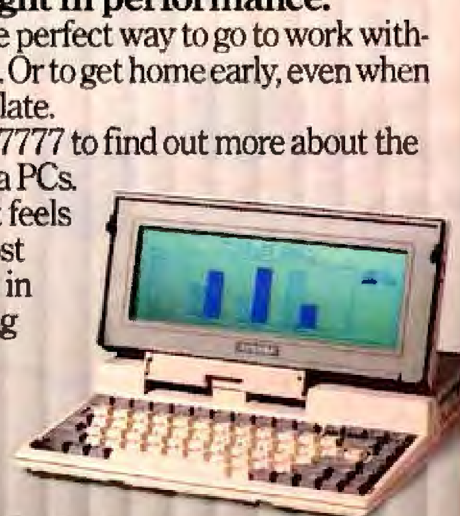

In Touch with Tomorrow

TOSHIBA

Toshiba America Inc., Information Systems Division

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

HP's NewWave Designed for "Seamless Integration" of Applications

Hewlett-Packard hopes to step into the vanguard of integrated IBM PC software development with its NewWave applications environment. A version for developers ships this month, the company said. NewWave is a graphical, icon-based environment for working with and integrating data from multiple applications. The core of NewWave is the Object Management Facility (OMF), which enables users to produce compound documents that can contain data from multiple sources and of different types, including text, graphics, voice, and scanned images. Each type of data is an "object" in the document. NewWave keeps track of the objects' source applications.

While Microsoft's Windows 2.0 and Dynamic Data Exchange (DDE) allow linking of data from different applications, NewWave extends this capability by making the integration "seamless," or invisible to the user. Using "hot connects" between applications, any modification of an object automatically updates other related objects. Modifications performed within an application appear simultaneously in the compound document. The important distinction between OMF and DDE is that NewWave "remembers" the links. It maintains "persistent links," in the words of HP's Bill Crow.

At a demonstration, HP representatives illustrated "seamless integration" with a document that contained text from a word processor, part of a spreadsheet from Lotus 1-2-3, and a graph from HP's Drawing Gallery product, which graphs the 1-2-3 data. All these data types are objects that can be manipulated or modified directly in the document. For example, to change the data in the spreadsheet, you move the mouse pointer to the spreadsheet image in the document. After you double-click the mouse, Lotus 1-2-3 appears on the screen with the spreadsheet data. You modify the data, exit 1-2-3, and you're back in the document with the modifications automatically integrated. The Drawing Gallery graph is also automatically updated.

While NewWave can run any MS-DOS application, software developers must write additional code to make an application and its data appear as a "seamless object" in the NewWave environment. The process of integrating DOS applications into NewWave is called "encapsulation," of which there are three levels. At the lowest level, the MS-DOS application can simply be run from within NewWave. This level requires virtually no additional software development. The application is simply added to the NewWave DOS applications menu.

At the next level, the data from a DOS application can be represented as a NewWave icon that you can place in any compound document. An icon's data can simply be "dropped" into a compound document by dragging the mouse. An important feature of second-level objects is that they can be "browsed" without the source application being loaded. For example, you could browse or inspect a spreadsheet or graphics image simply by selecting the object's icon. This capability could be very useful in a network environment in which some workstations may not have access to the source applications. This level of encapsulation requires "a few hours" of work for the software developer, according to HP representatives.

An example of the second level of encapsulation is a voice-mail system developed for NewWave by Forum Systems (Santa Barbara, CA). An electronic voice-mail message appears as an object in the NewWave environment, which, while mainly useful for electronic mail, could also appear as an object within a compound document. You could, for example, include in a document an icon representing a voice-mail message that could be "replayed" by the reader of the document.

At the highest level, the application is fully integrated into NewWave by "hot connects" and automatically updates related NewWave objects, as in the earlier spreadsheet example. This level re-

continued

Nanobytes

Feeling left out of those dinner-party conversations because everyone's discussing **neural networks** and you're still trying to figure out local-area networks? **DAIR Computer Systems** (Palo Alto, CA) has something that might help: a program called Netwurkz, which the company says is a neural net tutorial and simulation package intended to serve as an introduction to neural modeling and associative memory concepts. The $79.95 program runs on an IBM PC with 192K bytes of memory and MS-DOS 2.0 or higher. . . . We saw a prototype **electroluminescent** yellow-phosphor display, installed in a Dynamac portable Macintosh, from a Finnish company named **Lojha**. The Finlux MD640.400 is a flat-screen, high-resolution unit with a resolution of 640 by 400 pixels and a viewing area of 4.8 by 7.7 inches. It's only 0.7 inch thick and consumes less than 16 watts of power. . . . **Planar Systems** (Beaverton, OR) also has a **new electroluminescent display**, an EGA-compatible unit with a resolution of 640 by 400 pixels and a bright-yellow viewing space of 5 by 8 inches. The EL8358HR consumes from 5 to 10 watts. . . . Scientists at IBM's Almaden Research Center (San Jose, CA) say they've produced 3½-inch disks that can hold a mighty **10 gigabits** of information, which a spokesperson told Microbytes is equivalent to 620,000 typewritten pages. IBM also says that's more than 50 times denser than any disks on the market today. That's incredible, but several industry watchers said they'll get more excited when they see devices that can read those disks. . . . **Turbo-Power Software** (Scotts Valley, CA), which produces an add-on tool called Overlay Manager for

continued

Borland's **Turbo Pascal** 4.0, is working on a debugger for that language implementation. It will be called TDebug 4.0, a spokesperson said. . . . **Power R** (Seattle, WA) is selling a video adapter board and a "specially designed monitor" that looks an awful lot like an Apple IIGS monochrome monitor. That's because it *is* a IIGS monitor. But it's been modified to conform to **Macintosh video**. The $499 MacLarger monitor/board retains the 512- by 342-pixel Mac resolution but at a larger size. Power R says the board can be used with multiscan video projectors. . . . Ideas might be as easy to find as blackflies in New Hampshire in the springtime, but venture capitalists aren't. Infoprobe (Sunnyvale, CA) sells the **Venture Capital Directory** on disk (for MS-DOS machines). It lists more than 100 venture firms in California and what kind of ventures they like to spend their money on (89 percent say they're interested in computer- related projects, but only 9 percent are into real-estate endeavors). . . . **"The Microprocessor Report"** is a newsletter "for designers of microprocessor-based hardware," says editor/publisher Michael Slater, who in his spare time wrote a book called *Microprocessor-Based Design*. Subjects Slater and associates cover include coprocessors, slave processors, controllers, RAMs, FIFOs, development tools, and buses. Annual subscription price is $195. Contact MicroDesign Resources (Palo Alto, CA) at (415) 327-9273. . . . You're the **Unix** ace at work. All day long you're answering questions about vi and grep and awk. Well, you might want to point out to your colleagues that UniPress Software (a Unix software vendor) and Concentric Associates offer 22 courses aimed at helping users and organizations learn Unix. The **Unix Training Center** offers classes, at your site, for $100 per student per day (but there's a minimum of $1300 per day). For more information, phone (201) 287-2130. . . . **The Computer Musician's Source Book** covers products such as computers,

continued

quires fairly extensive development work, comparable to integrating an application into Windows 2.0.

NewWave also includes a built-in help facility that can be accessed by any integrated application. The developer needs only to write the text for the help facility and specify the appropriate context-sensitive index pointers.

The other main component of NewWave is an "automated task manager" called the Agent. The Agent is similar to a macro processor but can record commands applying to different MS-DOS applications. The Agent uses scripts written in the NewWave Task Language. You can use the Agent to schedule automatic execution of repetitive tasks at a particular date and time, for example.

The NewWave developers' toolkit will be available this month for $895, HP said. A five-day training class costs $1100; three months of telephone technical support costs $1000. The end-user run-time version of NewWave will be priced at $195 and will be available in the second half of 1988, according to HP. The NewWave system requires Windows 2.0 and at least 2 megabytes of RAM.

While NewWave further complicates the marketplace for software developers, HP believes it will be fairly easy for developers to build existing applications into NewWave. The big question, though, is whether developers, already faced with several environments to work in, will design programs for NewWave. HP spokespersons stated that a version of NewWave is in the works for OS/2 and that HP is working closely with Microsoft "to bring DDE and OMF closer together."

Algorithm-driven Computing Speeds Up Old, Slow Hardware

Just about every young computer company wants press coverage. But few get the kind of ink received by Saxpy Computer Corp. (Sunnyvale, CA), which recently made the news when an employee was arrested on espionage charges for allegedly selling secrets to the Soviets. At first, many technologists were skeptical of the government charges, believing it was just another attention-getting ploy on the part of the feds. As details about Saxpy and its Matrix 1 supercomputer architecture became known, however, those skeptics began to express concern. "Maybe the Russians really did get something after all," one engineer said to Microbytes.

What is so surprising about the Matrix 1 supercomputer, and what makes it ideal for Soviet applications, is that it is based on "old" hardware technology, hardware that is close to where Soviet supercomputing currently is. Consequently, the information the Soviets bought may enable them to squeeze higher performance out of their old hardware.

"We make no bones about it," Saxpy vice president Joe Straub said. "Our hardware technology is old and slow. It is really amazing that we are able to attain such speeds with relatively slow technology."

What Saxpy has focused on, and what the Soviets may now have access to, are advanced algorithms that enable slower architectures to perform at supercomputer speeds of up to 1000 million floating-point operations per second (MFLOPS). Saxpy claims, for instance, that the Matrix 1 can perform at the same rate as a Cray-2 and up to 10 times faster than a Cray X-MP/24. But because the Matrix 1 hardware is based upon commercially available components (unlike the Cray), the price is much lower. A Matrix 1 is priced at between $900,000 and $1.8 million, while a Cray-2 runs from about $8 million to $25 million. The Matrix's standard TTL and ECL components not only contribute to a lower price tag, but they also enable a smaller size, lower power requirements, and an air-cooled design that does not require special refrigeration.

"In designing the Matrix 1, we intentionally tried to limit the hardware technology and tried to use off-the-shelf components," said Straub. "Most of our work is in the algorithms."

By focusing on the software instead of the hardware, Saxpy is able to implement a computing strategy called "matrix computing," in which structured algorithms are used to process large, multidimensional blocks of data. The Saxpy approach links up to 32 parallel pipelined processors, creating a single-instruction, multiple-data (SIMD) architecture to work on up to six dimensions of a problem simultaneously. The processor can perform up to 32 floating-point multiplications and 32 floating-point additions or subtractions simultaneously. The system runs under the VAX/VMS operating system and is programmable in FORTRAN-77, C, Pascal, and Ada.

continued

software, keyboards (like on a piano), and other music hardware; runs articles like "Ethical and Legal Use of Software"; and lists user groups and dealers and manufacturers. The book is put out by the **Computer Musicians Cooperative** (Peoria, IL) and costs $75. Phone (800) 342-5246; in Illinois, dial (309) 685-4843. . . . **Analog data-acquisition interfaces** for personal computers is a big-bucks business, according to Venture Development Corp. (Natick, MA). The consulting firm says total shipments of such interfaces were worth $141 million last year. Demand for analog D/A plug-in boards will be greater than for add-on chassis and modules, the company projects, because of their lower cost. . . . And for our finale this month, some **hyperquotes** from hypertext pioneer **Ted Nelson**:

On the Macintosh: "The Macintosh is simply a paper simulator. Think of all the virtual forests we've cut down to supply Macintosh screens. We have deforested the American mind, my friends."

On CD-ROM: "Information lords offering information to information peons."

On his own foresight: "In 1960, I was sure screens would replace paper publishing by 1963. I was always in the forefront, but that was 27 years ago."

On what it takes to be a good programmer: Programmers who prefer to drive a shift car are not "positioned to design interactive systems. Shift cars are an inane complication in the process of going forward and backward."

On the concept of databases and spreadsheets: "Compartmentalized and stratified fields produce compartmentalized and stratified minds."

On user-friendliness: "I have enough trouble socializing with people. I don't need some object saying 'good morning' to me."

Definition of the "chipmunk mentality": "People rushing to the next copy of BYTE to find the next table of instruction sets. There is very little importance in instruction sets."

So far, the Matrix 1 supercomputer has been used primarily for solving complex scientific and engineering problems, most of which involve signal processing. The federal government, for instance, is using the Matrix 1 to simultaneously process several radar signals to more accurately determine the speed, location, and size of an object that's being tracked.

"Matrix computing is a new type of computing," said Straub, "and we believe it will move the technology forward."

Will Hypertext Save Mankind?

Calling hypertext "the next step in literature," the man considered the concept's creator urges software developers to adopt his approach. In a recent rambling presentation to the Software Entrepreneur's Forum in Palo Alto, California, Ted Nelson offered his Project Xanadu as a "back end" for software applications using his concept of "nonlinear, nonsequential" text, linked in a global "docuverse" that will eventually store millions of documents accessible to millions of users. Nelson's Project Xanadu presently consists of about 135K bytes of compiled 68000-based C code, which runs on Sun and Apple Macintosh machines.

Hypertext, said Nelson, "is a literary concept and a cultural watershed. Hypertext is an ongoing parade of documents, linked to previous documents and pointing to future ones." Nelson envisions an enormous local area network linked to "Xanadu file servers," in which millions of people can participate, writing and reading information at "mom and pop Xanadu stands" all over the world.

"The present-day computer world stinks," said Nelson. "What we see out there is an unholy mess; thousands of incompatible files and programs created by artificial distinctions between program types." In Xanadu, there is no distinction between text, databases, spreadsheets, or any other data structure. Xanadu is a "write-once" system in which every entered document is assigned an address in a huge, virtually limitless address space. The Xanadu address structure consists of document addresses and document "spans" (groups of documents), which are linked by a new mathematical system called Tumbler Arithmetic, Nelson said.

Not only does Nelson propose to revolutionize the way computers are used; he proposes to save the human race. "The objective is to save humanity before we send it into the garbage pail. We must remove the TV-induced stupor that lies like a fog across the land." Nelson said he wants to "make the world safe for smart children."

"Xanadu is not a conventional project," Nelson said. "This is a religion. The proper person is one whose mind is free to roam." (For more Nelsonisms, see this month's Nanobytes.)

What's a Company Like Lotus Doing at a Show Like Wescon?

Despite all its talk about Corporate America, Lotus Development (Cambridge, MA) was the only major mainstream PC-related company exhibiting at the recent Wescon, a show known for the latest in components, subsystems, and testing equipment used in the electronics industry. Because Lotus is more closely associated with MBAs in three-piece suits than engineers with pocket protectors, the software company's presence surprised many Wescon attendees.

Lotus' modest booth was certainly unlike the glitzy exhibit it hauls to expos like COMDEX and was probably unlike any Lotus exhibit in recent years. When was the last time you saw a Lotus booth crammed with oscilloscopes and function generators?

The company was promoting the use of several Lotus products—Measure, Symphony, Manuscript, and Freelance Plus—in automated electronic test environments. Lotus had connected a PC AT to a series of electronic test equipment (multimeter, voltage source, oscilloscope, and function generator), which was in turn connected to an amplified low-pass filter circuit that was being tested.

In the demonstration, Measure, which supports IEEE-488 bus and RS-232C serial communication protocols, was being used for both control and data acquisition. Measure was used to set up the voltage source and measurement instruments by applying various voltages and measuring the voltage and current. A macro was used to determine the saturation limit for the transistor by

continued

setting the voltage, then reading it using the signal generator and oscilloscope. Another test determined the frequency response of the low-pass filter, while a third test determined the characteristic curve of the transistor. As data was acquired, it was dumped directly to a Lotus spreadsheet for analysis, a process that was automated by macros.

Once the testing was completed, reports were generated using Manuscript. The sample reports included data, such as the sample number, the raw data, and the converted value of the data generated from the oscilloscope and taken from the spreadsheet. That information was presented in tabular as well as in graphic form.

Database/Graphics Program for Producing Technical Reports

One of the biggest bottlenecks for geotechnical and related engineering firms has been creating graphic-intensive reports that require text, illustrations, and standardized industry symbols. At times, graphic artists need to produce 50 or more detailed diagrams of bore holes and wells for a single report, with most diagrams taking up to 3 hours to draw. Since late reports can result in government fines of up to $10,000 per day, engineering firms are looking for better ways to generate documents.

GeoTechnical Graphics (Berkeley, CA) is attacking this problem with its soon-to-be-released program, called GTGS (for GeoTechnical Graphics System), which integrates database information and graphic output. With GTGS, highly technical diagrams and reports that take professional artists hours to create can typically be generated in less than 10 minutes, the company said.

"GTGS lets us go straight from the data to publishable-quality reports," said GeoTechnical principal Jodene Goldenring.

According to Goldenring and developer Bruce Krumland, there is nothing about the program core that restricts it to geological reports. It could be used to produce any report that is technical in content and requires complex text and graphics. Although the initial versions of the program—which runs on a PC AT or compatible—work with Hewlett-Packard plotters, subsequent versions will support laser printers. Single-user versions of GTGS will sell for less than $2000, while a network version will sell for less than $3000.

The program consists of two integrated components, a database module and a report-generating module, both of which are flexible enough to be customized for virtually any application. In addition to standard storage provisions, the database is optimized for data common to geology and hydrology. As with any database program, data is entered through forms, although it can also be imported from Lotus 1-2-3, dBASE, and so on. All data originating from a single boring is kept in individual data files. ("Each file describes everything that comes out of the hole," said Goldenring.)

At the heart of the report module is an HPGL-compatible plotting language called GTGL, written by Krumland, that provides control over plotter functions (e.g., pens, line types, and font

continued

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designs). Reports are generated via plotting templates that contain the graphics routines necessary to create a report.

The program has no on-screen graphics. The plotting module, for instance, uses a text interface and conventional WordStar-like dot commands. Data can be entered and modified using a built-in text editor. For previews, GTGS has a "dry run" feature that compiles the plot and checks for errors.

"This is not a CAD system," said Krumland. "We are trying to get away from CAD, where data stays with the picture because it is the picture and you can't do anything else with it. With GTGS, once you enter the data, you can manipulate it any way you want."

Twelve Volumes of English Words Now on Two CD-ROMs

It took 44 years to publish it on paper, but significantly less than that for it to appear on a shiny CD-ROM disk. Tri Star Publishing (Fort Washington, PA) has released a CD-ROM version of the mammoth *Oxford English Dictionary*, originally published by Oxford University Press between 1884 and 1928.

According to Tri Star, every word of the 12 large volumes of the dictionary, plus index, has been installed on two CD-ROM disks, taking up 800 of the 1200 possible megabytes available on the two platters. The disks are divided into the ranges A–N and O–Z. Users can, of course, search for any dictionary entry as they would in the paper version, but the CD-ROM edition will also allow users to search for specific words in the definitions, the etymological descriptions, or the many quotes that enhance the definitions.

One example query: Find every entry that includes quotes by both Shakespeare and Milton that contain either the words "education" or "knowledge." This Boolean searching capability may come in handy, especially considering that many of the dictionary entries can be rather long—some run longer than 60,000 words.

Don't count on being able to look up words such as "compact disk," or even "computer." The OED, as literary types call it, is so massive that it has not been revised since the last volume was finally published back in 1928. Supplements have appeared since then, but they aren't included in the CD-ROM version.

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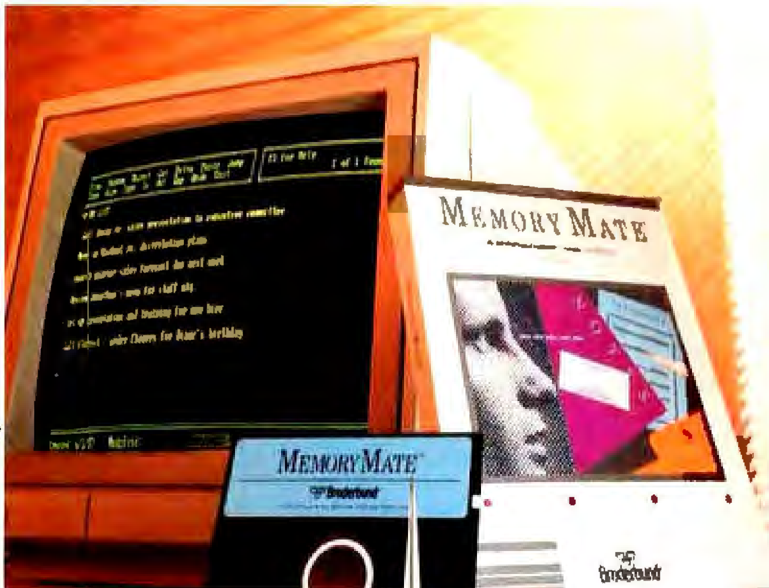

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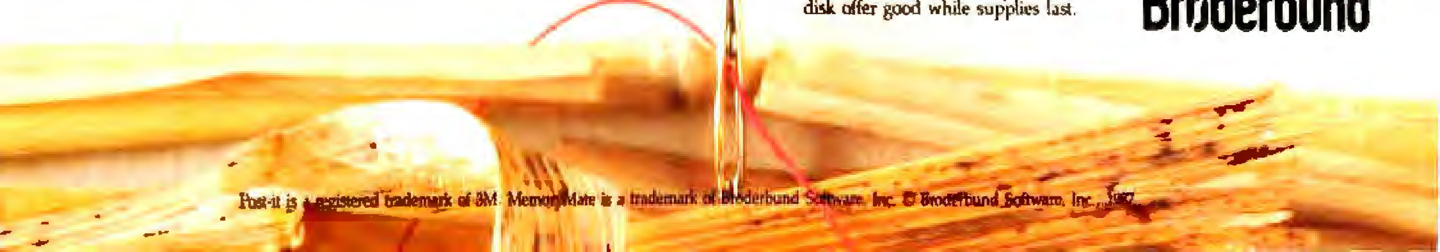

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LETTERS

Shifty CRCs

Jerry LeVan's article, "A Fast CRC," (November 1987) could be made a bit less shifty. While I thoroughly enjoyed the text, I made three observations while melding the technique into my modem control.

If an odd 8-bit packet is sent, a zero byte must be padded to orient the cyclic-redundancy check correctly. This procedure is necessary only at the transmitting end.

Table value (0 hexadecimal) XOR 1088 is table value 128 (80 hexadecimal). All other values follow this format. A test for sign bit on the incoming byte could incorporate this factor. It shortens the table but will add extra time to the code loop.

Finally, the electrical analog uses only one 8-bit shift. I could not see why the program analog needed two. The following tables show that the program, too, needs only one.

Table 1 was generated using CRC-CCITT format X16+X12+X5+1: equal to 1021 hexadecimal. The CRC of data bytes 07, 08, and 09 (70e7, 8108, and 9129, respectively) is shown below.

Table 1: *Code for one 8-bit shift.*

Old code		New code	
@1 move.b	(a)+d1	,get char	@1 move b (al)+d1
move.w	do,d3	;crc now	eal w #8,d0
1sr.w	#8,d3	,position	
eor.w	d1,d3		
add.w	d3,d3	,indexer	add w d1,d3
move.w	0(a0,d3.w),d3	,tbl val	
isl	#8,d0	,position	
eor.w	d3,d0	;new crc	eor w 0(a0,d3.w),d0

0000 shifted left 8 is 0000, so:
XOR 70e7 equals 70e7
70e7 shifted left 8 is e770, so:
XOR 8108 equals 6678
6678 shifted left 8 is 7866, so:
XOR 9129 equals e94f

The odd packet must be shifted left 8 to equal 4fe9, the final transmittal data. At the receiving end,

4fe9 shifted left 8 is e94f;
this XOR 70e7 equals 99a8
99a8 shifted left 8 is a899;
this XOR 8108 equals 2991
2991 shifted left 8 is 9129;
this XOR 9129 equals 0000

In the 68000 assembly code, with which I am not too familar, I opted to use "eal" as the end-around-left shift mnemonic. Then the old code becomes the new code listed in table 1.

This variation works only for even-byte packets. Beyond these observations, I did not go.

Gerald M. Jesse
Port Washington, WI

The Spirit of C

I found Matt Trask's review of MetaWare's High C 386 compiler (November 1987) only partially accurate, and I think the conclusions were completely misleading.

I have used High C 386 (versions 1.3 and 1.4) extensively, and I agree with most of the negative arguments: It has poor support for Unix-style file I/O, unintelligible compiler error messages, and differences from Unix C.

However, the review states that High C 386 can be used only with Phar Lap's Run386. High C does not require Run-386. It requires a 386 linker (Phar Lap's is the only one I know of) and a 386 run-time environment (A.I. Architects' OS/386, IGC's VM/Run, or Phar Lap's Run386, aka the DOS Extender). Moreover, Run386 fully supports High C 1.4.

Optimization is listed as one of High C's main features. Unfortunately, a bug in the optimizer hooked to the `Auto_reg_Alloc` flag generates bad code. MetaWare just sent Viewlogic a fix that solves the problem.

As far as conclusions go, the review completely misses the issue. No one I know considers High C 386 an alternative to Microsoft C (which doesn't support the 386). It would be more reasonable to compare it to the Xenix 386 C compiler. Developers of large applications need High C to access the large address space of the 386, while coexisting with DOS applications. Memory, and the speed and grace with which you can access that memory, is the real reason for using High C 386. Source code generally needs some minor modification, and the compiler takes some getting used to, but, overall, High C is an immensely useful product for those who need it.

Dan Smiley
Viewlogic Systems Inc.
Marlboro, MA

No one I know considers High C 386 an alternative to Microsoft C, either. Since there is no comparable product against which to measure High C, I chose to use Microsoft C for comparison because most C programmers are familiar with it. This way, a potential High C user can get a feel for the time it takes to compile typical code and some insight into the quality of the code in MetaWare's run-time library. As you can see from the published benchmark, Microsoft's floating-point functions are more efficient than MetaWare's, and the compiler takes longer to translate the same source.

Your statements that "the compiler takes some getting used to" and "source code generally needs some minor modification" sum up the essence of my conclusion in the review: This product misses out on the spirit of C programming.

—Matt Trask

continued

LETTERS POLICY: *To be considered for publication, a letter must be typed double-spaced on one side of the paper and must include your name and address. Comments and ideas should be expressed as clearly and concisely as possible. Listings and tables may be printed along with a letter if they are short and legible.*

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Workstation Identification

In Phillip Robinson's generally good article "A World of Workstations," (November 1987), table 1 has several errors.

For the IBM RT PC, the unit shown as model 6160 is a model 6151, and all of the units shown have been superseded by the units 6151 Model 115 and 6150 Model 125, introduced in February 1987. The performance figures (given in MIPS) are correct for the new model numbers. The new models come standard with 4 megabytes of memory and a 68881 floating-point unit (FPU). The 10-MHz NS32081 FPU shown was never standard and is still available as an option, I believe, but many of the other products in the table have optional floating-point boards that are not listed. RT PC memory expansion is to 16 megabytes of memory, not to 4, as shown.

For Sun Microsystems, the Sun-3/160 is a 16.67-MHz CPU and 16.67-MHz FPU system. The numbers shown in the table seem to belong to the Sun-3/260, which is not listed in the table. The 3/160 and 3/260 are similar but distinct product lines. For the Sun-4/260, the reduced-instruction-set computer (RISC) chip is commercially available from Fujitsu, so it probably should not be considered a "proprietary RISC chip."

Although the chart has only so much room, some of the systems are shown with their minimum hard disk capacity, while others are shown with their maximum capacity, and the number of hard disks also varies with the system (Apple Mac has one internal hard disk drive, for example, while the IBM RT PC can have three). Most diskless systems have optional hard files, and most systems can have floppy disk drives, while only the Apple Mac listing shows a floppy disk drive.

David Wilson
Humboldt, AZ

APL Fibonacci

The letter from Douglas Ross ("Forth and the NC4016," Letters, December 1987) caught my eye this month, as I have been learning Forth. However, I am writing in regard to another language and its Fibonacci Benchmark Program (FBP) results.

The language is APL, specifically STSC APL*PLUS version 7.0 run on an AST Premium 286. Please refer to listing 1a for a "conventional" version of the FBP. By "conventional," I mean one that loops through the main program 100 times.

While the times compare favorably to those given in Mr. Ross's table, this exercise has reduced APL to just Another Programming Language. Where APL

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gains a decisive speed advantage is in its ability to work on vectors or arrays of numbers. Please refer to listing 1b for an "APL" version of the FBP. By "APL," I mean one where the main program is executed only once but operates on 100 rows of numbers at one time.

Both versions are quite similar, save for these three differences made to the "conventional" version to arrive at the "APL" version. Lines 1 and 5 are removed, since looping is not required. Lines 2 and 3 set up and execute 100 rows of numbers at one time. Line 4 is modified to check for 24 columns rather than 24 numbers.

The end result is a program that runs 10 times faster and is 40 percent smaller (note that the "APL" version may be smaller, but the value calculated (SEQ) will be 100 times larger than the "conventional" version). Refer to table 2 for a complete set of timings.

An interesting side point is the use of the 80287 math chip. Since the only arithmetic involved is addition, its presence does little to increase speed. However, change line 2 in listing 1a from "1" to "0.1" and line 3 from "+—" to "*" (raise to a power), and the speed advantage becomes more apparent.

What started out as purely a machine comparison and moved on to a machine/software comparison has now ended up as a software comparison. I certainly do

continued

Listing 1: *A conventional implementation of the Fibonacci benchmark (a). An implementation more typical of the way APL operates (b).*

(a)

```
    ∇ FIBC;CTR
[1]   CTR←1 ⋄ ⍝                   SET ITERATIONS COUNTER (CTR) TO 1
[2]  L1:SEQ←1  ⋄ ⍝                SET INITIAL SEQUENCE (SEQ) TO 1
[3]  L2:SEQ←SEQ,+/¯2↑SEQ ⋄ ⍝  ADD LAST TWO VALUES OF SEQ, CATENATE TO SEQ
[4]   →(24>⍴SEQ)/L2 ⋄ ⍝          CHECK TO SEE IF 24 NUMBERS HAVE BEEN DONE
[5]   →(100>CTR←CTR+1)/L1 ⋄ ⍝ CHECK TO SEE IF 100 ITERATIONS HAVE BEEN DONE
    ∇
```

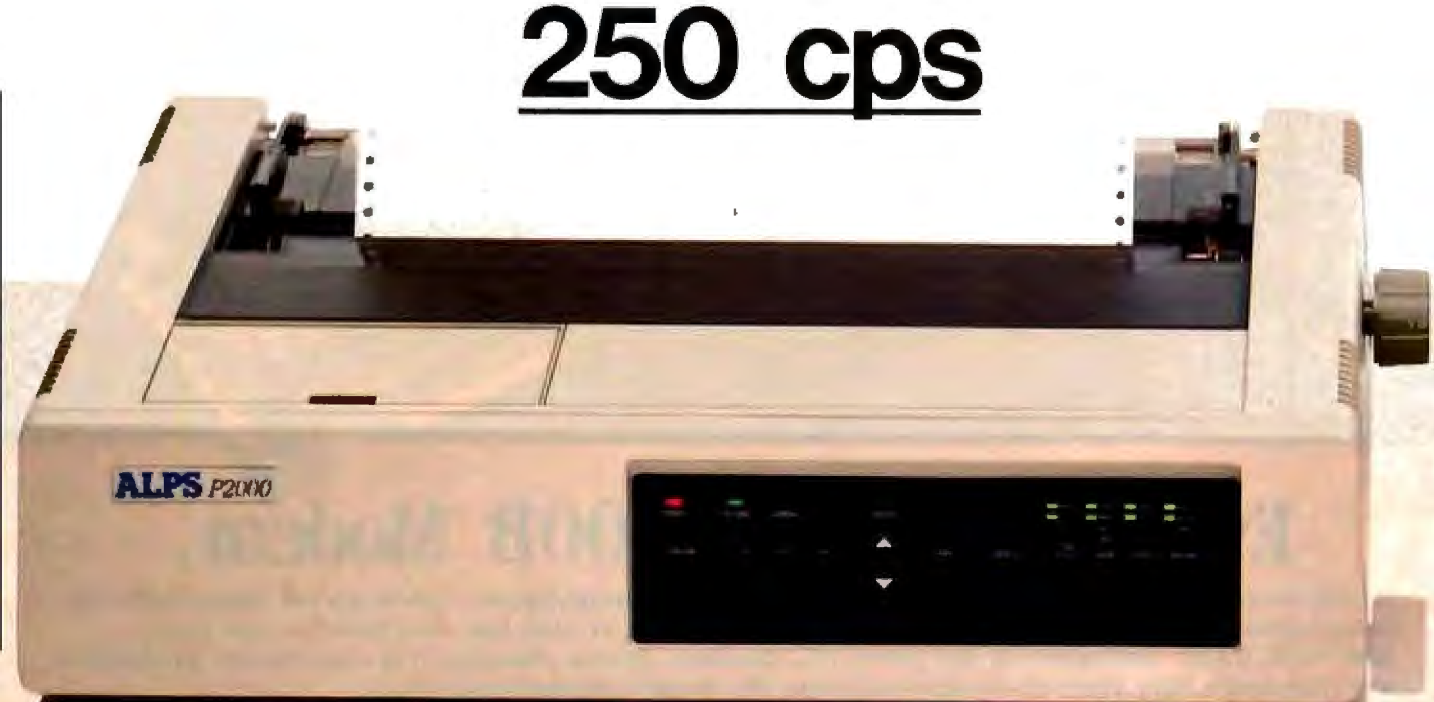
(b)

```
    ∇ FIBA
[1]   SEQ← 100 1 ⍴1 ⋄ ⍝               SET INITIAL SEQUENCE (SEQ) TO 100 ROWS OF 1
[2]  L2:SEQ←SEQ,+/100 ¯2 ↑SEQ ⋄ ⍝ ADD LAST TWO VALUES OF SEQ, CATENATE TO SEQ
[3]   →(24>¯1↑⍴SEQ)/L2 ⋄ ⍝            CHECK TO SEE IF 24 COLUMNS HAVE BEEN DONE
    ∇
```

Table 2: Fibonacci results for APL.

System using "conventional" APL		Time (seconds)
AST Premium	6-MHz 80286	24.91
AST Premium	6-MHz 80286 w/8-MHz 80287	24.72
AST Premium	8-MHz 80286	18.35
AST Premium	8-MHz 80286 w/8-MHz 80287	18.24
AST Premium	10-MHz 80286	14.63
AST Premium	10-MHz 80286 w/8-MHz 80287	14.56
System using "APL" APL		
AST Premium	6-MHz 80286	2.47
AST Premium	6-MHz 80286 w/8-MHz 80287	2.45
AST Premium	8-MHz 80286	1.83
AST Premium	8-MHz 80286 w/8-MHz 80287	1.81
AST Premium	10-MHz 80286	1.47
AST Premium	10-MHz 80286 w/8-MHz 80287	1.46
System using "conventional" APL with ".1" and "*" modification		
AST Premium	10-MHz 80286	30.87
AST Premium	10-MHz 80286 w/8-MHz 80287	16.05

THE FASTEST
TO AN



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not want to start a "my software is better than your software" contest (we have enough of those with 68xxx vs. 80xxx challenges). My intent is only to pass along these thoughts:

There is always one more way to skin a cat (and if you are in the cat-skinning business, it doesn't hurt to try a new way every now and then).

Not all cats look like cats, and just because it looks like a cat doesn't mean it is a cat (so be sure you really have a cat before you start skinning).

Unless somebody is paying you to skin all those cats, why worry how you do it or how long it takes (unless, of course, it makes you feel good)?

John Hamilton
Des Moines, IA

Reviewing Actor

Having read Leonard Moskowitz's review of Actor 1.0 (September 1987), we would like to make your readers aware of changes in version 1.1.

All known bugs in 1.0, including those cited in the review, have been fixed. Version 1.1 also addresses the problem of insufficient memory with more efficient code generation and memory use. As a result, version 1.1 provides 90K bytes more room for users than version 1.0 did. In a standard installation, over 100K is available to run other Windows applications. Under the small (run-time) image, approximately 200K is available for the application. This gives users plenty of room to use device drivers, such as networks, along with Actor. Version 1.1 has been tested and runs on Windows 2.0 and 386, which can make use of extended memory.

To some extent, Actor's speed depends on Windows's ability to draw graphics images quickly. Windows 2.0 has improved the performance of graphics operations by several hundred percent. In addition, Actor's internal speed has been improved via peephole optimization up to 50 percent over version 1.0.

The reason for the caveat regarding `cleanup()` and dynamic memory mentioned in the review has been eliminated. Actor now uses the disk for cleanup, so users can safely use Actor with a much lower dynamic memory setting (typically 25K to 30K bytes).

The so-called user interface inconsistency claimed in the review is there because we felt that people had different expectations of an interpretive workspace window (immediate feedback) as opposed to a file editor (new line). Overall, our design decision seems to have been confirmed by feedback from our users.

The display window now retains a log of all text printed in it; consequently, messages can never be lost. The problem mentioned with scrolling of window captions is a bug in Windows, not Actor, and it has been fixed in Windows 2.0.

On the documentation front, our manual was virtually rewritten. We have also implemented a new site-license policy for universities whereby they can purchase a single copy of the software for $99 and then purchase a manual for $35 through an authorized representative.

Version 1.1 also has a number of new features. For instance, Actor now includes a debug window to examine stack frames, browse messages, inspect variables, and resume any messages sent. C structure objects are now available for communication with C libraries or DOS. We also have incorporated many suggestions from our users to improve the usability of system tools.

Actor 1.1 is available for $495 to nonacademic customers.

Chuck Duff
President
The Whitewater Group Inc.
Evanston, IL

continued

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Riding the Tiger

Regarding the December Editorial ("The 'B' Word"), I'm happy to hear that BYTE has grabbed the tiger (computer benchmarks) by the tail in an attempt to bring some sense into these ("so important") computer system performance test and evaluation programs.

I hope BYTE doesn't rush into developing a new series of test programs and that there is some period of time allotted to evaluate the test programs (benchmarks) themselves. These test programs must be impeccable. So often I have found benchmarks that are flawed in some manner or another (even those designed by experts of the highest caliber). It is very frustrating, because one is never sure what is really being tested or if a comparison of one system to another is even valid.

Al Aburto
San Diego, CA

Shifted Integer x × 2

Larry Ozeran's proposal (Letters, November 1987) for a new "shifted integer" data type is similar to a modified floating-point format I recently designed for a hand-held data-collection device. Like Mr. Ozeran's, my precision requirements were modest (four decimal digits). Unlike him, I needed to deal with numbers ranging over several orders of magnitude.

I used a standard 16-bit two's complement integer for the mantissa and an unbiased 8-bit integer for the exponent (power of 2). This scheme has the advantage that 8-bit microprocessors easily manipulate these quantities. Also, since the implicit binary point is at the far right of the mantissa, you can float any integer by simply suffixing a zero exponent byte (the routines do not require that numbers be maintained in normalized form).

The range of quantities that can be represented with full precision is from ± 32K $2^{(-128, +127)}$, or roughly from 10^{-34} to 10^{43}. Actually, this was far more range than I needed, but packing and unpacking smaller exponents would significantly slow arithmetic operations.

Ozeran's choice of a power of 10 exponent is curious, since it drastically complicates the processes of normalization and alignment. Indeed, if, as he says, "values you might compare all have the same exponent," then why bother storing it with each value at all? Simply stick it in a data table header and let the analysis routines deal with it post facto.

Rob Lewis
Hollywood, CA

Information Source

When I recently decided to buy an IBM PC-compatible computer, I also bought all the MS-DOS books at my local bookstore. One of those books happened to be a BYTE book—*Introducing PC-DOS and MS-DOS: A Guide for Beginning and Advanced Users* by Thomas Sheldon (McGraw-Hill, 1988). This book is extremely well written, with very clear examples to explain the various commands and how to use them.

I'm still not an advanced user, but, thanks to the book, I now feel more at ease with my PC. I highly recommend *Introducing PC-DOS and MS-DOS* to any beginner who feels that his or her PC is resisting all efforts to understand it.

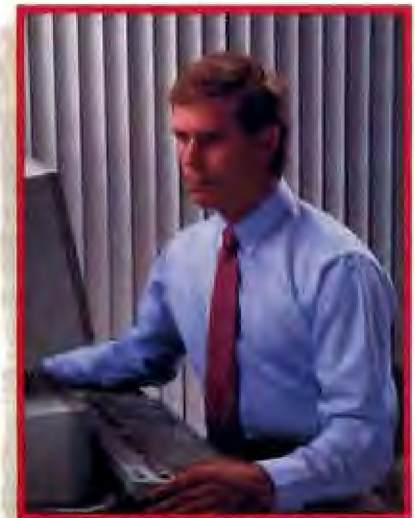
Pat Hollin
Florence, Italy

FIXES

Price Fix

Letraset USA alerted us to the fact that ImageStudio sells for $495 rather than $49.95, as stated in What's New, December 1987, page 96. ■

Print Master lets people share printers



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CHAOS MANOR MAIL

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

Missing Manuals

Dear Jerry,

In your August 1987 column, you mentioned a growing serious problem that I hope you will continue to give prominent attention to. You noted that Kaypro no longer provides technical manuals with its products, and that this has caused some grief. I was disappointed that you did not more stridently take Kaypro to task for this omission. It is a very serious problem. Whenever I purchase a piece of equipment that does not come with schematics and other technical details, I immediately write the company for that material (agreeing to pay, of course). Alas, I am finding more companies unwilling to provide the information at any price.

Two recent cases: Datavue would provide only barely readable schematics (with a missing page yet), nothing else, after I signed a nondisclosure agreement! Can the company really be serious in believing that this will prevent copies? So far, Western Digital has ignored my letters for information on its Portafile hard disk drive with SASI-SCSI port. As your experience with Fast Kat indicates, seldom does the equipment operate as advertised, and without schematics and manuals, there is often no way to know if the equipment is faulty or some handshaking is missing. It took a technician 6 hours to get the Portafile to talk to a Compaq. The step-by-step setup procedure was for a genuine IBM PC, and somehow it choked when applied to the Compaq. The Datavue still goes off into hallucinations in terminal mode, apparently because some garbage is stored in battery RAM, which the manual does not say how to clear—or for that matter does not even mention directly.

I trust that you will continue to aid the consumer by complaining loud and clear about the lack of technical documentation for hardware.

Robert W. Harrington
Ann Arbor, MI

You're right, of course. Full-service manuals ought to be available to any user. Both Kaypro and Zenith used to provide them routinely, which is one reason they became two of my favorite companies. Now they don't. They say most people don't want them, and some people are intimidated by them.

My own view is that the companies ought to have an option on the registration card: Fill in a credit card number, and for $20 the manufacturer will send the schematics, service manuals, and other hard technical data. The fee would discourage casual requesters.—Jerry

Greetings from Europe

Dear Jerry,

Why do the makers of MS-DOS laptops insist on putting 3½-inch disk drives in their machines? Now I either have to get a 3½-inch drive for my home computer or do without a laptop.

About a year ago, in a fit of Gadget Lust, I bought a Panasonic Executive Partner, a nice machine with 5¼-inch disk drives. It has performed, as you would say, yeoman service during the past year. But, between the permanent grooves in my shoulders and the 3 inches that my right arm has stretched (all from the machine's 30-plus pounds), I have no love of it as a traveling companion. It doesn't even fit under my airline seat—contrary to the promises of the sales rep.

Toshiba *used* to make its T1100 (now the T1100 Plus) with 5¼-inch drives. But, along with the nice, new display, the company put in those nasty 3½-inch drives. I cannot find a plain T1100 (or any other laptop with 5¼-inch drives) at any of the mail-order houses.

Not much to report from this hemisphere. The Bundespost just raised the cost of data-transmittal services. Instead of pricing transatlantic data communications just beyond the reach of mortals, it's priced it so only the heirs of Howard Hughes could currently use the service. So, between the data fees and the BIX fees, I am not likely to become a BIXen anytime soon. Frustration abounds.

International marketing faux pas: The Soviets try to buy their American technology from third and fourth parties whenever possible. My company cooperates with them in two ways. First, there is an inde-

continued

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

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BY28

pendent marketing and support group set up especially for the "East Block." Second (and more amusing to those of us who get to watch), a firm in India has an interesting connection to ours. It seems that the Indian gentleman who wholly owns the firm was able to push through some sort of executive, lifetime agreement to market our products in the subcontinent. Our company has no rights and many responsibilities, while the Indians get to run things their own way.

So, business being what it is, a lot of high-tech equipment gets to the East Block through the Indian firm (and India in general, but that is another story). The Soviets are tickled to be able to pay for their shiny new gear with rupees, which the government of India is happy to get back, because India has about the same balance of trade problems with the Soviets that the U.S. has with Germany.

Back to the faux pas. The Soviets wanted to buy a lot of laser printers. But common Soviet paper is barely adequate for typewriters, much less Canon engine-based throwaway printers. So, they decided that one of our rugged printers would suit their needs. And the marketing boys (Americans on "assignment" to the Indian company) went nuts with the sales proposal. The Soviets declined to buy, and no one could figure out why. In the meantime, a Japanese firm beefed up its laser printers to handle the Russian paper and sold about 5000 units.

What happened? Well, the nearest that those of us who care can figure out is this: The Indians had set up a very nice package for the Soviets: a fully optioned laser printer with lots of image memory, parallel and serial ports, the latest internal ROMs, and spare parts. It also included a photocopy capability, integral to the printer.

In a society that controls copy machines like other societies control plutonium, you can imagine the horror that ran through some bureaucrat's mind when someone tried to sell him small, possibly portable copiers. The requirement for "laser printer" was overridden by "copier." To the few of us who heard about the fiasco, this was not an immediately obvious answer. But a few cool ones crossed the table one night and (as they often do) assisted the intellectual process.

What does this have to do with anything? Well, I believe that the main reason that American firms do so poorly in the world market is that American marketing styles are too narrow-minded. If you ask me, American sales reps, for the most part, do not take the time to get to know their market. What may sell a leather jacket in Peoria may well get a salesperson landed in jail in Malaysia—or laughed right back to the airplane.

With few exceptions, most non-American firms set up their sales forces in the local economy and insist that their people get to know local practices and priorities before starting out. Provincial American business attitudes preclude this. Rather than studying the competition and doing their jobs better, U.S. businesses, it seems, prefer to cry "Foul" and hide behind the skirts of government—childish and, in the long run, dangerous, both for the cowardly firms and us consumers.

If our planet is to run its economy in a free market system, everyone has to play by the rules. The European community is beginning to show its stagnation in that respect. When the European Economic Community was formed 20 years ago, a series of protective tariffs and quotas was put into effect. These measures, designed to ease the transition to a truly European economy, were to expire in 1992. But in the European parliament, a great move is afoot to extend that date indefinitely. Everyone is deathly afraid to compete on equal terms with the other guy.

Chuck Kuhlman
Mannheim, West Germany

Thank you. I always enjoy your reports from Europe.

As for portables, I have never liked 5¼-inch disks; for my money, they ought to put at least one 3½-inch drive in every new desktop computer. You can store more small disks than large ones, and they hold more. They're also a lot more rugged. With Traveling Software's Laplink, there's no problem getting from desktop to portable anyway.—Jerry

Prolog for Sundog

Dear Jerry,

In your September 1987 column, you discussed using Q&A to build a database for Sundog, pointing out Q&A's flexibility for this application but lamenting its lack of capability to help with information such as estimates of commodity prices and determination of the best trip to make.

You and your readers may be interested in knowing that Prolog provides the flexibility that Q&A seems to have in storing data while also offering the computational abilities you desire.

My program is written in Turbo Prolog. Prolog directly implements relational databases, and two are used in the program. The first is `location`, which is used to record the planet and solar system where a city can be found. The second relationship is `actual_price`, which holds the prices found in the exchanges. The program doesn't include them, but you could easily add relationships to record the location of exchanges, the availability and prices of ship and computer parts, and assorted information. With the interactive environment provided by Turbo Prolog, setting up these databases and entering the data would be easy—possibly as easy for Q&A, although the screen displays and reporting would be less fancy without some real programming.

You can see the advantage of using Prolog for Sundog support when you try to get help in figuring out the most profitable deals. That's where `estimated_price` comes in. This portion of the program estimates the price of a commodity of a specified grade based on `actual_prices` of the same commodity in the same city. `Profit` uses the `estimated_prices` to calculate the profit that one could make by hauling a commodity between two cities. Finally, `best_trip` figures out the best of all possible trips by comparing the profitability of all potential trips. As a bonus, the slight modifications of `best_trip` that follow the main version (which is first in the listing) allow you to determine the best trip given a specified starting city, ending city, or load.

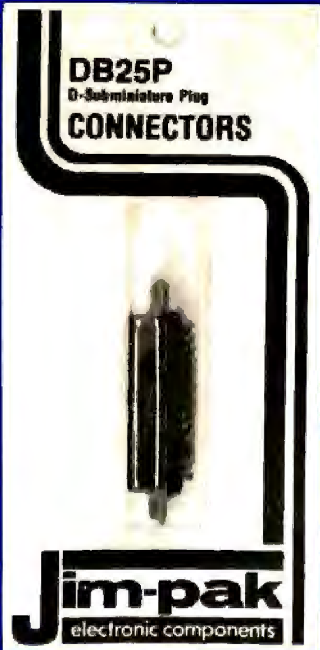
This example illustrates the power of Prolog as a prototyping tool: It lets you create databases easily, and programs that you've written for one purpose can be used for others. Thus, unlike a conventional programming language, a function can be used to derive its outputs or inputs. For example, `profit` calculates the return from a proposed trip and also generates all trips meeting specified conditions. The ability to reuse functions can greatly multiply the effectiveness of your programming effort.

Roy E. Lowrance
New York, NY

By coincidence, I have been reading Dan Shafer's Turbo Prolog book and playing about with the language, and I had come to the conclusion that I could probably do what you suggest. Thank you for the neat example. I can hardly wait to try it out.

I am fast concluding that Turbo Prolog should be the first language that many people learn. It has considerable power; alas, if you have learned a procedural language first, you may run into trouble grasping Prolog concepts. I did, until I got Shafer's book.—Jerry ■

[Editor's note: *Mr. Lowrance's program, JERRY.PRO, is available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents. You will need an IBM PC or compatible and Turbo Prolog to run the program.*]



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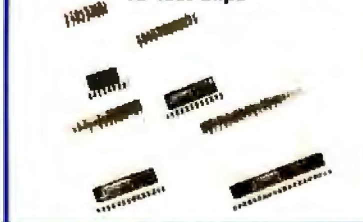

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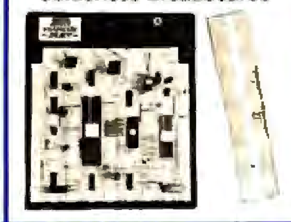

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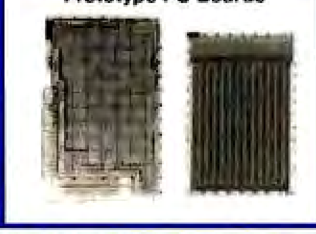

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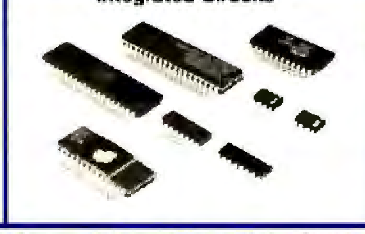

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ASK BYTE

Steve Ciarcia answers your questions on microcomputing.

Disturbing Numbers

Dear Steve,

I am experiencing some disturbing activities while using Borland's Turbo Pascal version 3.01 on my IBM PC clone (it has an 8088 chip with no 8087). My problem concerns the arithmetic functions TRUNC and FRAC. For example, if I set N1=11.0, Turbo Pascal tells me that TRUNC(N1)=11 and FRAC(N1)=0.0, as it should. However, when I then go and set N1=2.2*5.0, Turbo tells me that TRUNC(N1)=10 and FRAC(N1)=1.0. I tried the same example using FORTRAN 77's INT function, and it worked fine.

I am sure the problem is in the accuracy of the multiplication of the two numbers, but the question is, how can I avoid this unacceptable result? I need to use these functions on a regular basis. Should I write my own multiplication algorithm?

Douglas Jones
Fort Walton Beach, FL

Welcome to the wonderful world of numerical analysis, where things are never quite what they seem. Consider the simple elaboration of your problem in Turbo Pascal 3.02A (no math coprocessor):

```
PROGRAM TestNums;

VAR
    r1,r2 : REAL;
    r1t,r1f : REAL;

BEGIN
    r1 := 2.2 * 5.0;
    r1t := Trunc(r1);
    r1f := Frac(r1);
    r2 := 1.0 - r1f;
    Writeln(r1:15:11);
    Writeln(r1t:15:11);
    Writeln(r1f:15:11);
    Writeln(r2:15:11);
END.
```

The results are:

```
11.00000000000
10.00000000000
 0.99999999999
 0.00000000001
```

Surprised?

It turns out that the number 2.2 doesn't have an exact representation as a binary fraction; the 0.2 part is a nonterminating fraction when expressed in binary. Turbo Pascal maintains about 11 decimal digits of precision, so while the exact value for r1 *is really 10.99999999999..., it displays as 11.00000000000 because Turbo Pascal rounds off its internal representation to 11 digits and fills with trailing zeros.*

The binary-coded-decimal (BCD) version of Turbo Pascal may be some help, because it uses decimal base encoding for fractions. The fraction 0.2 has a terminating decimal representation (0.2000..., of course), so you'll get the right answer in this case.

But all is not roses. Even with the BCD version, guess what happens when you try

```
r1 := 1.0 / 3.0;
r2 := r1 * 3.0;
```

R1 *is 0.333333333333333333 and* R2 *turns out to be 0.999999999999999999 instead of 1.000... because the BCD version holds only 18 digits of precision and the fraction 1/3 isn't a terminating decimal fraction.*

If you have a pocket calculator, you might try some simple operations such as 3 × (1/3) and see what comes out. They're all done in BCD in 8 to 10 digits, so you'll be able to figure out what's going on fairly quickly. Expensive calculators (notably from Hewlett-Packard and Texas Instruments) go to great lengths to handle these problems, but you can force the issue to show up by integer subtractions at the right points. Try 1 − (3 × (1/3)) and wince.

There is no way around this, simply because there are no "real" numbers in a computer. The real numbers you declare as REAL *are only approximations to the actual values, limited by the number of bits assigned to them in RAM. In some languages, you can have "long reals" with more digits, but that simply postpones the problem.*

FORTRAN 77 has, I believe, longer reals and rounds a little differently than Turbo Pascal. You might want to try recoding the example the way I did and see what happens. I suspect that you will get similar results.

Now, to be fair, the difference between 0.999... and 1.000... is pretty moot. If your application really cares about the difference, you'll need to remember that the numbers you're working with are approximations.

It may be worth your while to check out some books on numerical analysis from a university library. The subject is pretty tricky, and you would be well advised to brush up on your math first, but there's a way around most of these problems if you're serious.—Steve

PC Security

Dear Steve,

I have a security problem. At my workplace we have two IBM PC-compatible computers, each one with a floppy disk drive and a hard disk drive. I must control the access to the computers in three levels.

First, I have to keep nonauthorized personnel from using the computers. Second, I must keep people who are authorized to use only the floppy disk drive from using the hard disk drive. Third, I need to control access to subdirectories on the hard and floppy disks.

I need to do this without locks and keys if possible. The computers are in service 24 hours a day, 7 days a week.

Samuel Bolanos
Guadalajara, Mexico

Security in personal computer systems is becoming a fairly big software industry. A check of buyer's guide issues of magazines will give you a list of many sources for password-protection and en-

continued

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

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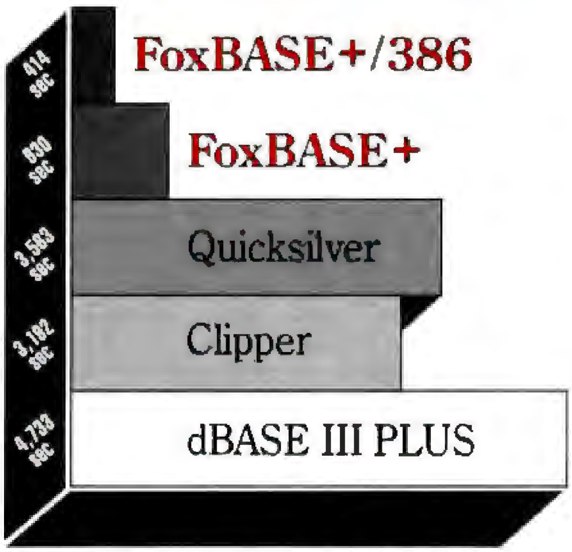

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*Using the benchmark timings published in BYTE, September 1987.
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cryption software.

Most security software seems to be of the data-encryption type, where anyone can access the file, but you need a code key to make the contents readable. This probably does not meet your requirements. There are, however, some programs that provide for password protection against unauthorized access to hard disks and directories.

Here are several companies whose advertisements I've seen recently:

Computer Security Corp., 2400 West Devon, Chicago, IL 60659, (312) 761-1764. This company produces three programs: Citadel, Sentinel, and 1st Guard Security Systems. All three programs offer both password protection and encryption.

Data Resources Protection Inc., 3663 Arnold Ave., Naples, FL 33942, (813) 774-3282. Softlock is for password protection and encryption.

H-F Computing Services Inc., 191 Eglinton Ave. E, Suite 302, Toronto, Ontario CD M4P 1K1, Canada, (416) 485-5403. HFTools For File/Directory Security offers password protection for individual files and sudirectories.—Steve

Just a Few Million Pixels

Dear Steve,

I have an idea that I would like you to consider. I use my computer to generate mathematical graphics—fractals and the like. I currently output these to a plotter, driving it back and forth as though it were a raster device. I would like to create higher-definition color output, ideally onto photographic film. The commercial services that do this sort of thing (some use the Matrox system for business presentations) have high enough resolution, but they will accept only the output of the software that they use.

Assuming that all the photographic stuff was taken care of, all I would need would be a small monochrome flat-faced CRT and whatever it takes to transfer the information a color at a time. I presume you get different intensities of the RGB of each pixel by lighting up the pixels for varying times. There are issues of exposure linearity and possible reciprocity failure that I would have to consider, but it seems to me that they would be manageable.

I would like such an object to accept its data via a generic serial link, since I am in transition between an IBM PC compatible and a Mac II. This project sounds as though it needs on-board memory, although I am not sure if I can create entire pictures at once or if I can do a part at a time. I would like to shoot for resolutions of 2000 by 2500 pixels.

Do you think this is something that an amateur could construct for a few hundred dollars?

Henry Casson
Portland, OR

You've got exactly the right idea for how the high-resolution slide film machines work: a very high-resolution monochrome display and a set of color filters. And, yes, gamma correction and reciprocity failure problems crop up—all those ugly real-life issues that we'd love to gloss over.

Unfortunately, there isn't a cheap way to get high resolution; it requires precision electronics, custom optics, and fussy mechanical contraptions. But perhaps I can meet you halfway.

If you'd like to play around with the idea just to see how it works, get an ImageWise receiver and a good NTSC monitor (see the May 1987 Circuit Cellar). It's got somewhat low resolution for your purposes (244 lines of 256 pixels each), but you could get really fantastic color renditions: 64 shades for each of the red, green, and blue exposures, for a total of a quarter-million colors (less any lost to reciprocity and so forth). It would give you a relatively inexpensive set of electronics to let you worry about the color filters, optics, and film cameras. Best of all, ImageWise is a serial device, so it will work with your IBM PC or your Mac.—Steve

CIRCUIT CELLAR FEEDBACK

Switching Supplies

Dear Steve,

Thumbing through old BYTEs, I came upon your article entitled "Switching Power Supplies: An Introduction" (November 1981).

I have been out of electronic design for some years, but now I have to return to the study of it, and one obvious problem I am facing is the design of adequate power supplies for my equipment (some of which is battery-backed).

Your article brought me partially up to date again, but I wonder if today you would use the same components as you did over 6 years ago. What's the news on the latest devices for this application?

Uwe Brunjes G. Gerente
Chihuahua, Mexico

My article on switching power supplies was written as a tutorial, intended to explain and illustrate the essentials of switching supplies "from the ground up." The power-supply design featured

continued

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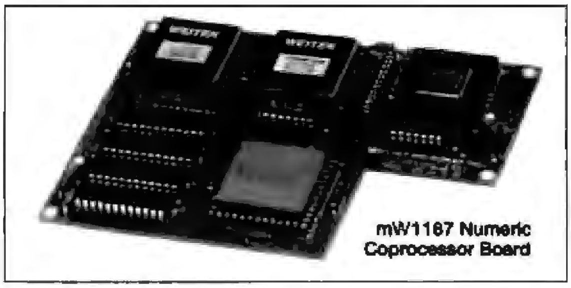

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The compilers are presently available in two formats: Microport Unix 5.3 or MS-DOS as extended by the Phar Lap Tools. MicroWay will port them to other 80386 operating systems such as OS/2 as the need arises and as 80386 versions become available.

The key to addressing more than 640 kbytes is the use of 32-bit integers to address arrays. NDP Fortran-386 generates 32-bit code which executes 3 to 8 times faster than the current generation of 16-bit compilers. There are three elements each of which contributes a factor of 2 to this speed increase: very efficient use of 80386 registers to store 32-bit entities, the use of inline 32-bit arithmetic instead of library calls, and a doubling in the effective utilization of the system data bus.

An example of the benefit of excellent code is a 32-bit matrix multiply. In this benchmark an NDP Fortran-386 program is run against the same program compiled with a 16-bit Fortran. Both programs were run on the same 80386 system. However, the 32-bit code ran 7.5 times faster than the 16-bit code, and 58.5 times faster than the 16-bit code executing on an IBM PC.

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was intended in this spirit. If I were designing a power supply intended for mass production, I might have selected somewhat different components, based on manufacturing considerations and the economies of scale.

If I were writing a tutorial to illustrate the same things, I might or might not make some minor changes in the design. With many new and exciting integrated circuits available with various features and functions, I would study what is available in terms of functional specifications, then make a decision according to what I found. The essential principles remain the same regardless of the specific design employed. Switching regulators are available from several manufacturers, including giants like Motorola as well as smaller companies, and each has its features from an engineering or product-design perspective.

You can obtain components for the experimenter's supply described in the 1981 article from several sources, although the core for the hand-wound inductor is difficult to obtain in small quantities. Advertisers in BYTE such as Jameco Electronics and JDR Microdevices can often supply parts—the 78S40 switching regulator, for example, is available from Jameco. Inductors of various values are available from Mouser Electronics (2401 Highway 287 N, Mansfield TX 76063) and DIGI-KEY Corp. (P.O Box 677, Thief River Falls, MN 56701-9988).

For newer variations on uses for switching supplies with EPROM programmers, see the serial RS-232C programmer (February 1985) and the 8052-based intelligent programmer (October 1986) featured in Ciarcia's Circuit Cellar.

The following books contain detailed treatments of the subject of switching regulators and power supplies: Switching and Linear Power Supply, Power Converter Design *by Abraham I. Pressman (Hayden Book Co., ISBN 0-8104-5847-0) and* Electronic Principles *by Albert Paul Malvino (McGraw-Hill, ISBN 0-07-039867-4). Also, manufacturer's data and application sheets are usually good sources of both general information and specific circuits.—Steve*

Help Convert Me

Dear Steve,

In "Build an Analog-to-Digital Converter" (January 1986), you included plans for a 16-channel, 12-bit high-speed ADC board. Can this design be readily converted to operate on an IBM PC (8086) bus? I can envision many home uses for such a board if I could adapt it to my AT&T PC 6300 using something like a JDR Microdevices prototype board with decoding layout as a start.

I'm a chemist, and I'm familiar with analog electronics and Turbo Pascal. However, I'm not too good at digital design. Any help would be appreciated.

David W. DeBerry
Austin, TX

Adapting the 16-channel 12-bit ADC board design to an IBM PC can be done—very easily, in fact. You can use most of the design as is, or nearly so. The only area that really needs to be changed is the host CPU interface, reflecting the difference between the BCC-52 and PC buses. For example, you could drive the ADC1205 RD and WR* signals by the PC bus IOR* and IOW* signals.*

One additional option you might consider is to exploit the IBM PC's direct-memory-access (DMA) capability. This would allow you to access the ADC at maximum conversion speed—about 10,000 samples per second.

However, DMA would complicate the circuitry somewhat—you have to generate a PC DRQ (DMA request) from the ADC status bit that indicates conversion is complete and turn the PC DACK (DMA acknowledge) into an ADC data read. Actually, you would have to account for the fact that a DACK calls for two ADC reads—one for the most significant bits, and another for the least significant bits. Finally, I doubt BASIC could keep up with 10,000 samples per second—you'd probably need assembly language (or a compiled language like C or Pascal).

Since you mention home uses, which typically won't require such fast sampling, I'd ignore DMA the first time around. Later, after you have gotten a non-DMA version working, you could consider a modified design including DMA.

You could also use the PC's interrupt capability instead of the polling approach I used. However, this involves many of the same considerations as DMA (hardware and software complexity). Polling is fine for most applications.

With one of the many "Interfacing the PC" books and a National ADC1205 data sheet, you should be able to get something working fairly easily. Also, when you talk to National, ask for an ADC0808 data sheet. The 1205's 12-bit resolution is actually overkill for most home applications. Instead, the 0808 offers only 8-bit resolution but combines eight channels on one chip, eliminating the need for the multiplexing logic on the BCC-30.

A diagram in the article entitled "Computer-Controlled Wood Stove" in

continued

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Ciarcia's Circuit Cellar, Volume II, *shows that connecting the 0808 to the IBM PC would be very easy.*
—Steve

More Conversions

Dear Steve,

I recently obtained a copy of your article entitled "Build an Analog-to-Digital Converter," and I want to learn more about A/D conversion and application.

I am an embryologist who wants to monitor environmental conditions during development of marine turtle eggs. However, I cannot afford to purchase an off-the-shelf system because they typically cost too much. I would like to buy components to assemble a more reasonably priced system, but I don't have the knowledge necessary to select the electrical components. I should state that I am a computer user, but not an advanced programmer.

Can you recommend a book that would fill the need of the "Dumb Biologists' Guide to Electronic Sensing and A/D Conversion"? I know that many of your articles have been collected into books, but they are not available here in Saudi Arabia. If you believe they would provide some of the guidance that I need, I'll gladly purchase them.

Some of my needs are as follows:

• A system that is rugged enough to sit in the sand for up to 3 months and collect a data set without disturbance. I would also use the unit in the laboratory, where conditions are usually better. I might need to be able to put it in a waterproof box. Data storage would require a memory module of some sort.

• The ability to collect data at set intervals. The shortest would be about 1 minute (on an oxygen probe), and the other probes would collect at about 5-minute intervals. I am willing to trade off time intervals for cost, if necessary. I would like to be able to select other, longer intervals (up to 6 hours) if possible.

• The ability to sample oxygen, temperature, moisture, salinity, and pH. Does a difference in probe output require different amplification?

Jeffrey Dean Miller
Dhahran Airport, Saudi Arabia

Unfortunately, I can't really recommend a book for you. I get most of my information from trade journals, manufacturers' data sheets, and so on. The books I read years ago in college tended to be long on theory and details, and short on real-world applications.

Actually, I've written many articles over the years related to A/D conversion

continued

and environmental sensing. These are reprinted in my Ciarcia's Circuit Cellar books, volumes I to VI. In all, about a dozen of the articles are related to A/D—everything from a "Computer-Controlled Wood Stove" (see preceding letter) to a "Computerized Weather Station" (right up your alley). In my new publication, "Circuit Cellar Ink," I present a series of projects to receive and display satellite weather maps.

The WESDATA recorder looks pretty good, but you could save a lot of money if you build your own. For example, take an HD64180 CPU, EPROM, eight 6264 static RAMs, and an A/D chip (such as the ADC0808)—and voilà, you have a low-power, 64K-byte, RS-232C data recorder. Of course, though the chips only cost about $100, whether it is worth it depends on the hardware and software design and debug time you'll have to put into it.

The issue you mention—sampling rate versus cost—has two facets. In general, increasing the sampling rate will increase the power consumption, which affects battery life. But using all CMOS chips practically eliminates this factor (just remember to use the HD64180 SLEEP mode between samples). In fact, because of the low power required and since it sounds like your system is outdoors, you might consider a battery-/solar-powered charger setup. This would have a potentially unlimited life, as long as the sun keeps rising every day.

However, the real potential problem is storage capacity. You mention sampling five factors, one every minute and the rest every five. You also state that the sample period could be up to 3 months. Without cranking the math in detail, that adds up to about 250,000 samples in 3 months. If each sample is a byte, you need 256K bytes. The 64180 can handle this (it has a 1-megabyte address space), but now you need 62256 (i.e., 32K × 8 static RAMs), which at least doubles the chip cost. Or you could use dynamic RAMs, with the understanding that power consumption goes way up.

Don't overlook ways you can reduce the amount of storage required. Take advantage of the intelligence of the CPU. For instance, do you need to store every sample, or can the CPU compute (and only need to store) an average for a period? Does everything need to be sampled with full (say, 8- or 12-bit) resolution? If not, have the CPU pack multiple samples in a single byte. Many samples may have small changes in value for sequential periods—have the CPU just store the temperature change from the last period (4 bits) rather than the absolute value (7 or 8 bits). You get the idea.—Steve ■

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BOOK REVIEWS

A PROGRAMMER'S GUIDE TO COMMON LISP
Deborah G. Tatar

THE SCHEME PROGRAMMING LANGUAGE
R. Kent Dybvig

THE LITTLE LISPER
Daniel P. Friedman and Matthias Felleisen

THE THIRD APPLE: PERSONAL COMPUTERS AND THE CULTURAL REVOLUTION
Jean-Louis Gassée

A PROGRAMMER'S GUIDE TO COMMON LISP
Reviewed by Alex Lane

Digital Press, Bedford, MA: 1987, ISBN 0-932376-87-8, 327 pages, $23

In its long lifetime, the Lisp programming language has been implemented in a number of dialects, each with its own set of adherents and detractors. The differences among these implementations, notes Deborah G. Tatar, author of *A Programmer's Guide to Common LISP*, range from the annoying (the user finds that common operations are called something slightly different) to the seriously troublesome (variable scoping is done differently in different Lisps).

The lack of a standard language resulted in the slow, painful flow of ideas from one Lisp center to another, and it was clear that a standard was needed. Over the course of 30 months, some 60 Lisp experts debated the merits and demerits of standardization, and, for better or worse, the Common Lisp specification (which has since become a de facto standard) was born.

In 1984, Digital Press published a complete Common Lisp language specification called *Common LISP: The Language*. Written by Guy L. Steele Jr., the book includes descriptions of some 800 functions. Although *Common LISP* is an indispensable book for Lisp programmers, it is dry reading and not much of an aid to those new to the language. Happily, *A Programmer's Guide to Common LISP* complements Steele's book by providing readable explanations and examples keyed directly to chapters and sections of Steele's book. *A Programmer's Guide to Common LISP* can be viewed as a companion volume to *Common LISP*, but it is robust enough to be read on its own.

The aim of Tatar's book is "to guide programmers through the difficult first stages of learning Lisp." A secondary goal is to provide guidance for programmers who are moving to Common Lisp from an older dialect. Although it admits to being an introductory book and assumes no knowledge of Lisp on the part of the reader, it is not a book for the neophyte programmer because it deals in depth with advanced computing concepts like data structures and bindings.

Lisp with Flair

A Programmer's Guide to Common LISP is neither the first nor the only book to address the Common Lisp language. Most of what you'll find here can also be found in other volumes. However, what distinguishes this book from several other texts on Common Lisp is that the author, who taught VAX Lisp while she was a senior software engineer at Digital Equipment Corp., manages to present the language with flair. Where other authors might use apples and oranges in their examples, Tatar uses quotes from Shakespeare and T. S. Eliot. While this alone says nothing about the quality of the examples, it does help hold the reader's attention through what otherwise could be a tiresome learning process.

The examples, by the way, seem to have been well thought out and ordered in the text. For instance, in a discussion of dynamic scoping, the first example in the text shows how a variable declared to be "special" in function A can be used by function B without being one of B's formal parameters. The next example refines this concept by showing how a call to function C can be placed between functions A and B without affecting their operation.

The book's more substantive examples do interesting and sometimes amusing things. Starting in the first chapter, three simple program examples—a filter, a simulation, and a program builder—take you on a brief tour of what you are about to learn without requiring that you understand what's going on. Later in

continued

Illustration by Rob Colvin

A Programmer's Guide to Common LISP *provides exercises at the end of nearly every chapter, and the solutions are in the back of the book, a welcome change from other texts.*

the book you are confronted with, among others, a program featuring a "cybernetic" animal that "eats" the 1s in a one-dimensional world of 1s and 0s, an animal guessing game, and a text formatter. The book's pièce de résistance is a toy expert system, complete with explanations and source code.

Detail and Depth

Tatar's detailed explanations are notable. For example, in a discussion of numbers, characters, and strings, she tells the reader that "¾ is treated as a number, but under most circumstances 3g4b is not." In a footnote, she explains that 3g4b *could* be a number if the base were set sufficiently high. Then again, in a discussion of a list-building function, the author deliberately uses poor style to write a function that creates palindromes:

```
(defun almost-a-palindrome (list)
 (list list (reverse list)))
```

Noting that using the same name for both a function and a variable is considered poor style, Tatar nevertheless reminds the reader of the different bindings a symbol may have and of how the appropriate binding is retrieved, depending on how the symbol is used.

The author treats her subject in depth, taking up such advanced constructs as `catch`, `throw`, and `unwind-protect`, the mechanisms of `package` and `module`, and the concepts of program comments and documentation strings. A quick glance through the indexes of Patrick Winston's *LISP* (2nd ed., Addison-Wesley, 1984) turns up none of these subjects.

A Programmer's Guide to Common LISP is visually easy to read. Different typefaces are used to distinguish Lisp code from explanatory text. Diagrams are used with effect to supplement the text in a number of places. I found the diagrams that accompanied the discussion of shadowing particularly effective, since, prior to reading this book, shadowing was for me a puzzling Lisp concept. Separate indexes of defined procedures and macros and a general index make finding things easy.

Each chapter is divided into sections and subsections, with appropriately formatted section headings. Chapter highlights are listed at the end of each chapter and consist of a list of major concepts presented in the chapter, a summary of new syntax, and the previously mentioned suggested reading that refers the reader to Steele's *Common LISP*. The author also provides exercises at the end of nearly every chapter, and the solutions to all exercises are in the back of the book, a welcome change from the "solutions to odd problems only" provided in most texts. Tatar's stated purpose in doing this is to allow the reader to compare his or her working solution to the model solution and decide whether the differences lie in function or only in format.

Lisp is currently enjoying a surge in popularity due in part to a revived interest in artificial intelligence (AI) and in part, I think, to the acceptance of Common Lisp as a standard. Despite interest and standardization, however, the ranks of Lisp programmers could not increase substantially without good intro-

continued

ductory books like *A Programmer's Guide to Common LISP* to see them through the first stages of mastery.

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THE SCHEME PROGRAMMING LANGUAGE

Reviewed by Eva White

Prentice-Hall, Englewood Cliffs, NJ: 1987, ISBN 0-13-791-864-X, 242 pages, $22

Scheme is a simple yet powerful dialect of Lisp based on a small set of concepts: procedures, continuations, engines, conditionals, and assignment statements. Because Scheme is interactive and involves so few concepts, it is easy to become acquainted with the building blocks of the language, but it's difficult to understand how to use the language to its full potential. In *The Scheme Programming Language*, R. Kent Dybvig attempts to impart a mastery of the language to the reader.

The book is written for people who have some programming experience, though not necessarily with Scheme. Dybvig begins with an overview of the language and a tutorial introduction for people not familiar with Scheme. The tutorial takes the reader through the fundamentals of the language with code examples and exercises (answers to the exercises are not provided). The examples are written in an implementation called Chez Scheme, but I had little trouble running the code on Texas Instruments' PC Scheme.

The reference section of the book, some six chapters, groups functions together according to their purpose. For quick reference, an index in the back will direct you to the function you want: binding forms, control operations, and so on. The text describes the syntax for each function, clearly explains what the function does, and then uses the function in a short example.

In the final chapter, Dybvig gives the reader a good idea of how to write Scheme code. He presents six nontrivial applications, describes the programs, and follows the source code with exercises designed to stimulate thought and suggest possible extensions. The examples range from a matrix/vector/scalar multiplication package to a small abstract object facility that you can use as the basis for designing an object-oriented system. Happily, the author devotes an example to both continuations and engines. I found these concepts difficult to understand because they are not found in programming languages with which I am familiar. One example shows how you can use procedures as continuations to implement a pattern-matching technique called the unification algorithm, and the other shows how you can implement engines in terms of continuations and timer interrupts.

The Scheme Programming Language is not meant to be a standard language reference. While the author lists a summary of forms that are part of the standard subset, he refers the reader to other sources for the standard definition of Scheme and includes a useful bibliography.

The book's purpose is to give the reader an introduction to Scheme. That Dybvig achieves this goal and does it in a slim 242 pages is impressive.

Eva White is a technical editor for BYTE. She can be contacted at One Phoenix Mill Lane, Peterborough, NH 03458 or on BIX as "eva."

continued

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THE LITTLE LISPER

Reviewed by Gregg Williams

MIT Press, Cambridge, MA: 1987, ISBN 0-262-56038-0, 186 pages, $12.95

Most people would be hard-pressed to associate this new edition of Daniel P. Friedman and Matthias Felleisen's *The Little LISPer* with ancient Greece, though it is possible. The book teaches Lisp problem-solving almost entirely by the Socratic method—that is, teaching by asking the student questions. Although such a book requires more effort from the reader than other books would, the result is worth it: I learned more about Lisp from this book (greatly expanded from the 1974 edition) than I have from any of the other Lisp books I've read over the years.

One of Lisp's greatest strengths—and a major problem for those of us who know languages like Pascal, C, and even COBOL—is that it is designed to attack problems in a way more akin to mathematics and inductive logic than to top-down structured programming. While other books will tell you the mechanics of Lisp, they can leave you largely uninformed on the style of problem-solving for which Lisp is optimized. *The Little LISPer* teaches you how to think in the Lisp language.

The first words of chapter 1 set the tone with the question, "Is it true that `atom` is an atom?" This question is followed by the answer, "Yes, because `atom` is a string of characters beginning with the letter `a`." From there, the authors build by example an understanding of basic Lisp operators, the multiple uses of recursion, lambda functions, expression manipulation, and even some very advanced topics. The chapters are set in a two-column question-and-answer format, and the book asks you to write literally dozens of small Lisp programs.

Along the way, Friedman and Felleisen generalize what you've learned into Ten Commandments and Five Laws of Lisp, but this happens only after you have understood the same material through concrete examples. The dialect of Lisp used is closest to Scheme, but the authors list the corresponding operators in other dialects. Its interactive style helped me understand Lisp far better than simply reading about Lisp would have.

At $12.95, *The Little LISPer* is an inexpensive, enjoyable introduction to Lisp.

Gregg Williams is a senior technical editor for BYTE. He can be contacted at One Phoenix Mill Lane, Peterborough, NH 03458 or on BIX as "greggw."

THE THIRD APPLE: PERSONAL COMPUTERS AND THE CULTURAL REVOLUTION

Reviewed by Jack D. Kirwan

Harcourt Brace Jovanovich, San Diego, CA: 1987, ISBN 0-15-189850-2, 212 pages, $14.95

The first apple referred to in the title of *The Third Apple* is, of course, Eve's. The second is the one that hit Isaac Newton on the head, and the third is (no surprise) the personal computer. The author, Jean-Louis Gassée, works for Apple Computer, and he has written a delightful collection of essays on "these modern household gods."

Gassée is an unabashed computerphile, and his book is a lovesong to those amazing machines. In fact, Gassée often writes more like a poet than a computer executive: "If mainframes are associated with Pluto and the Underworld (implying

continued

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18011-A Mitchell South, Irvine, CA 92714 • (714) 261-0228 • TELEX: 386078 • FAX: (714) 261-0260 the death-dealing power of institutional wealth), microcomputers evoke the world of Apollo, of light and lightness, of buoyant individuality."

As a man of two cultures—France and California—Gassée offers some insights into their differences: "In France, failure is a no-no; if you go bankrupt, it proves you're a deadbeat, and no one will trust you. In Silicon Valley, if you fail the first time, they think you learned something and will be more careful next time around." For all its "brassy hedonism," Silicon Valley offers infinitely more fertile ground for new ideas than the Champs-Élysées.

"In the Labyrinth," the chapter that takes us into the internal workings of a computer chip, is one of the most fascinating parts of the book. Gassée's guided tour of this minuscule bit of silicon opens new avenues of understanding and appreciation. But in the last analysis, the personal computer is neither a god nor a superhighway. It is a kind of mirror; along those lines, Gassée confesses, "Computers fascinate me because they teach me who I am."

Revolutionary Thinking

For many readers, the important part of *The Third Apple* is probably not the personal computer essays but Gassée's "cultural revolution" thinking. If history teaches us anything about a cultural revolution stemming from technological change, it is both that the revolution is a lot slower than the enthusiasts hoped and that it usually zigzags in odd directions nobody would have predicted. The same holds true with computers. For a while (especially during the oil crisis), there was a lot of press coverage about people working at home in electronic cottage industries and revamping the workplace.

Congressman Newt Gingrich wrote eloquently in his book *Window of Opportunity: A Blueprint for the Future* (St. Martin's Press, 1984) about the advantages of computerized home education. Yet in April of 1987, the *Wall Street Journal* ran a feature about the unfulfilled promise of "cottage electronics" (mostly because old-school managers are uncomfortable not seeing their subordinates). College students still troop into classrooms to take notes from live lectures—just like in the eleventh century.

The reason for that unfulfilled promise is, of course, that there is a cultural lag between technology and its social application. Technology is comparatively easy to predict; the social applications—as anyone who is interested in good science fiction knows—is tough. For example, Gassée says, "Computers will not find the cure for cancer or hypertension by themselves. But they will definitely make their contribution, simply because they have made the information that already exists available to a larger number of people so that researchers will not have to repeat experiments." The book is salted with similar insights into how the computer has changed the nature of the operator's world.

In a way, *The Third Apple* is like the elephant in the fable of the blind men. Different readers—enthusiasts, futurists, business people, and so on—will read different parts of the book and claim that theirs is the totality. But Gassée's apple may not be for everybody's eye. Computer professionals might have wanted a bit more technical information, and seeing the name "Apple" on almost every page gets to be a bit much.

My biggest objection to the book had nothing to do with the words; the pages kept falling out of the binding. But, balanced against the insights, elegant writing, and overall charm of *The Third Apple*, this was a minor annoyance. ■

Jack D. Kirwan is assistant editor of The Energy Journal, *produced by the Department of Economics, University of Arizona, Tucson, AZ 85721.*

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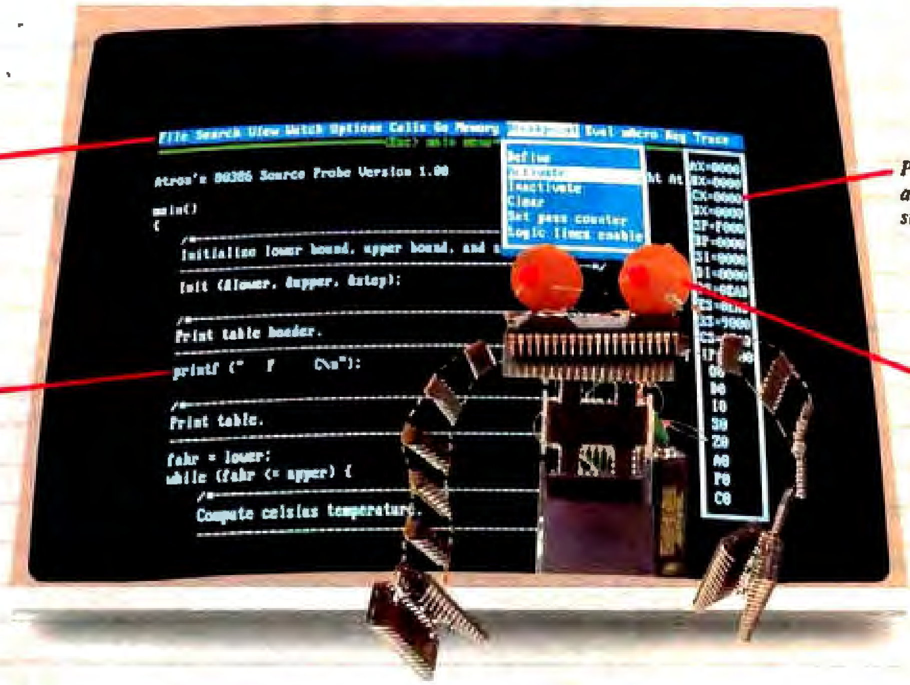

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Then, so you can look at the cause of the problem, the 386 PROBE automatically stores the last 2K cycles of program execution. Although other debuggers may *try* to do the same thing, Atron is the only company in the world to dequeue the pipelined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

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

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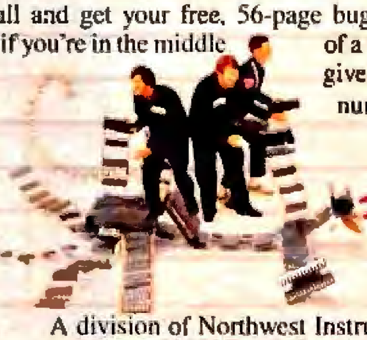

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SYSTEMS

The MP 286 is available in six different flavors.

Mitsubishi Zips to 12 MHz

The MP 286 Series 300 is Mitsubishi's collection of 80286-based AT compatibles, all of which run at 12 MHz (with one wait state). For those in less of a hurry, or for software that requires slower speeds, the Series 300 can be throttled down to 8 MHz with zero wait states, 8 MHz with one wait state, or 6 MHz with one wait state.

With a footprint of 15 by 15 inches, all Series 300 models arrive with 640K bytes of RAM that you can expand to 4 megabytes without using any of the system's expansion slots. Or, by adding Mitsubishi's 2-megabyte RAM expansion boards, you can expand the system memory to a maximum of 8.64 megabytes.

The Series 300 computers have six full-length expansion slots: four of the 16-bit variety and two 8-bit ones.

Systems shipped with a hard disk drive use one of the slots for the controller. A controller that will command dual floppy disk drives is standard, as is a clock/calendar and a socket for an 80287 coprocessor.

The six available configurations range from a Series 300 with a single 1.2-megabyte floppy disk drive and no monitor, all the way up to a loaded system with a 40-megabyte hard disk drive and an EGA monitor.

Price: From $1995 to $4095.
Contact: Mitusbishi Electronics America Inc., 991 Knox St., Torrance, CA 90502, (213) 515-3993.
Inquiry 751.

One Step Up

The T3200 is Toshiba's step up from its current flagship portable, the T3100. The T3200 adds a variety of features, including an 80286 processor running at 12 MHz, 1 megabyte of RAM, a 40-megabyte hard disk drive, and a 720K-byte 3½-inch floppy disk drive that's compatible with IBM PS/2 drives.

Other new features include a pair of internal IBM-compatible expansion slots. One is a full-length 16-bit slot, and the other is a half-length 8-bit one. There's also a socket for an 80287 coprocessor. And if you never seem to have enough memory in your system, Toshiba has an optional 3-megabyte memory card that plugs into its own dedicated slot, leaving the standard slots free for other uses.

Last, but not least, the T3200 has added an EGA display system, including a high-resolution gas-plasma screen and an EGA monitor port. The screen shows colors as four shades of gray and displays 25 lines by 80 characters in a resolution of up to 640 by 400 pixels.

Weighing 18¾ pounds, the T3200 measures 14½ by 4 by 15½ inches and runs on AC power only. It also includes ports for a parallel printer, an external disk drive, and an RS-232C device. On the software side, the unit is shipped with MS-DOS 3.3 and the Lotus Metro desktop manager.

Price: $5499.
Contact: Toshiba America Inc., Information Systems Division, 9740 Irvine Blvd, Irvine, CA 92718, (800) 457-7777.
Inquiry 752.

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Up to Eight 16-Bit CPUs in One

Running Concurrent DOS XM 5.2, CompuPro's MP 200 series, a parallel processing multiuser system, incorporates up to eight 16-bit processors. The series' modular architecture lets you easily upgrade the system's memory, storage, and processors.

The MP 200's main processor is an 11.25-MHz 80286. On each of the system's SP186 slave processor boards there's a 10-MHz 80186 processor and 512K bytes of RAM. You can expand system memory up to 7.25 megabytes and add as many as eight processor boards, each of which handles two users and executes applications in parallel with both the central processor and other users' processors.

CompuPro says more than 700 multiuser business applications are available for Digital Research's Concurrent DOS 5.2. Many MS-DOS applications will run under it as well.

The MP 200 series is available in five configurations, differing mainly by the number of slave processors. Besides the basic 80286 processor, all the configurations include a 16-slot enclosure, an 8-port I/O processor, 1 megabyte of RAM, 2 megabytes of cache memory, an 80-megabyte hard disk drive, a 40-megabyte tape backup unit, a 1.2-megabyte 5¼-inch floppy disk drive, and a parallel printer port.

Price: $13,700 to $19,000.
Contact: Viasyn Corp., CompuPro Division, 26538 Danti Court, Hayward, CA, 94545-3999, (415) 786-0909.
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Price: $249.
Contact: The Complete PC, 521 Cottonwood Dr., Milpitas, CA 95035, (408) 434-0145.
Inquiry 754.

New Technology Graphics Tablet

Charge Ratio is a technology developed by Summagraphics for its new Bit Pad Plus graphics tablet. Charge Ratio uses ratios of sensed areas in generating the coordinates of the stylus or cursor position. According to the company, it eliminates potential variation errors caused by changing the distance between the bit pad and the pickup. You can, for example, trace through documents and drawings that are up to half an inch thick.

The Bit Pad Plus has a 12-by 12-inch active area and comes with both a four-button cursor and a one-button stylus for input. Its bit-pad-format compatibility is supported by most popular CAD and graphics software packages.
Price: $495.
Contact: Summagraphics Corp., 777 State Street Extension, Fairfield, CT 06430, (203) 384-1344.
Inquiry 755.

The Bit Pad Plus uses Charge Ratio technology.

Commodious Storage for the PS/2 Model 25

If you own an IBM PS/2 Model 25, its maker left you with limited mass-storage options. But options do exist. Western Digital now has the PS25/20i, a 20-megabyte hard disk drive/controller kit for the Model 25.

The PS25/20i kit includes preconfigured cables and complete installation instructions. The controller uses one of the Model 25's two available expansion slots. The hard disk unit mounts inside the Model 25 chassis and consumes 12 watts of power.

The hard disk is preformatted and comes with diverse software, including an automatic installation program. There's also WDPark, for parking the heads, and a disk caching program called SpeedRead that lets you select the amount of RAM you want to use for caching. According to Western Digital, SpeedRead reduces the effective disk-access time to between 30 and 40 ms.
Price: $495.
Contact: Western Digital Corp., 2445 McCabe Way, Irvine, CA 92714, (714) 863-0102.
Inquiry 756.

A Couple of 2400-bps Laptop Modems

Higher-speed (namely, 2400-bps) modems for laptop computer systems are quickly becoming the norm. Here are two cases in point:

NEC now has a 2400-bps internal modem for its popular MultiSpeed laptop. The unit is called, not surprisingly, the NEC MultiSpeed modem. It switches automatically between 300, 1200, and 2400 bps. It will also auto-answer, autodial, and support both answer and originate modes.

The modem uses an Intel 80C97 digital signal processor and is fully compatible with the industry-standard AT command set. It also has a built-in speaker whose volume is controlled by software. The NEC MultiSpeed modem is both Bell 212A- and 103A-compatible, as well as compatible with the European CCITT V.22 2400 and 1200 standards.

Weighing a tiny 3 ounces, the modem fits inside NEC's MultiSpeed, MultiSpeed EL, and MultiSpeed HD.
Price: $499.
Contact: NEC Home Electronics U.S.A. Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
Inquiry 757.

Meanwhile, if you own a Toshiba portable, you might be interested in a modem called the AdaptaModem from a company called Product R&D Corporation. Zooming along at 2400 bps, the unit, officially named the M24/Comms, is an internal unit that fits into the Toshiba T1100+, T1200, T3100, T3200, and T5100.

The M24/Comms is simple to install; all you need to do is to slide it into the computer's internal modem slot. The modem has low-power CMOS circuitry and consumes only a half-watt of power. It also includes a single RJ-11C jack, and it uses the computer's own speaker for call-progress monitoring. The company says that it's fully compatible with the AT command set.

For those times when you don't need a modem but do need a second serial port, there's a slide switch on the M24/Comms that switches it between modem and RS-232C serial port operation.
Price: $499.
Contact: Product R&D Corp., 1194 Pacific St., Suite 201, San Luis Obispo, CA 93401, (805) 546-9713.
Inquiry 758.

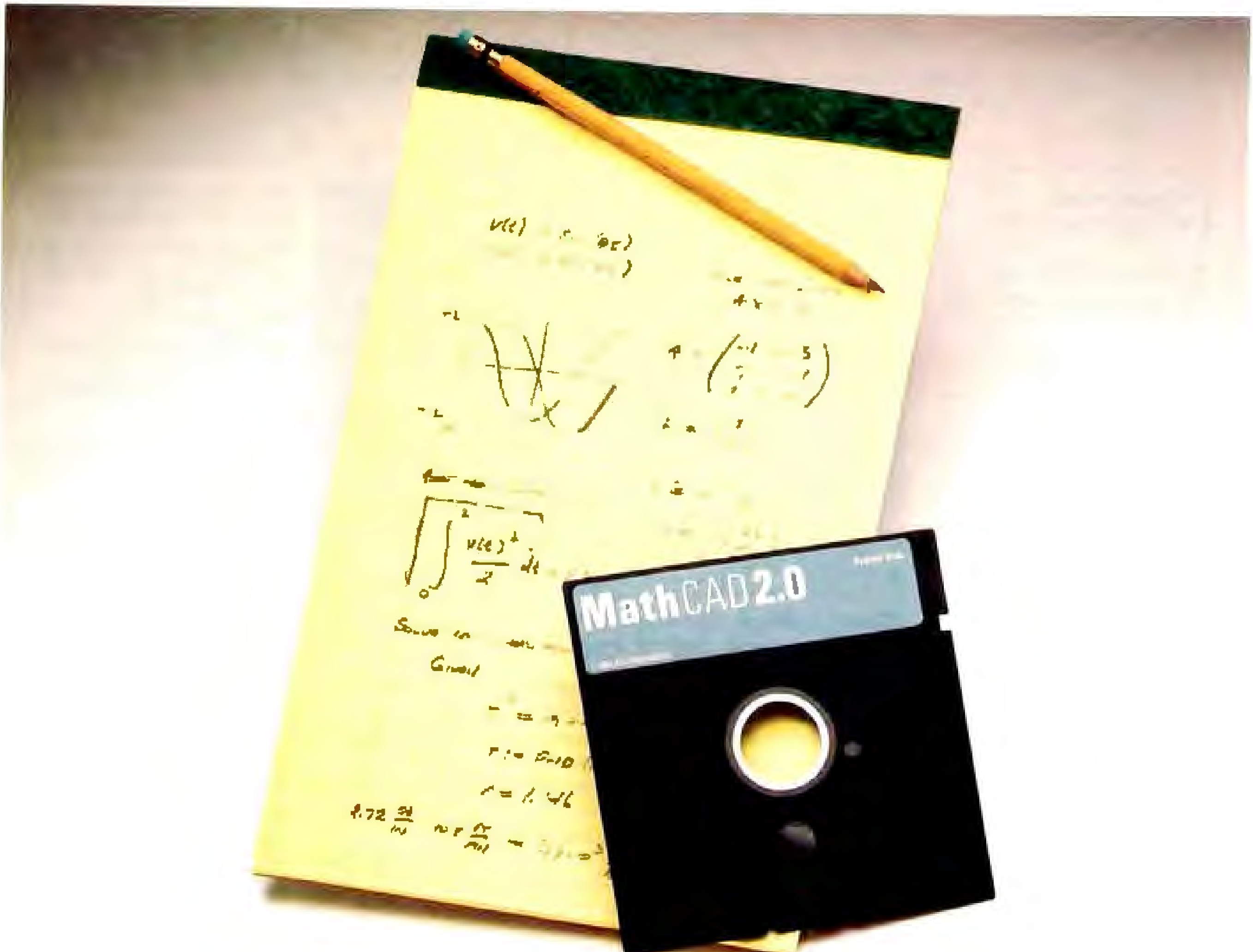
Half-Height CD-ROM Player

CD-ROM players are getting smaller. An example is the CDR-3500 from Hitachi, which takes up only a standard half-height slot in an IBM PC, AT, or compatible.

With a standard capacity of 552 megabytes, you can install the CDR-3500 either horizontally or vertically. It uses the same supply voltages as a standard floppy disk drive, and there's a daisy-chain connector on the drive that lets you hook up to four of the drives together.

And if you want to use the drive for musical pursuits while not accessing data from a CD-ROM, the CDR-3500 can also play back standard CD audio disks. There's a headphone jack with volume control on the front and audio outputs on the rear panel.
Price: $899.
Contact: Hitachi Sales Corporation of America, 401 W. Artesia Blvd., Compton, CA 90220, (213) 774-5151.
Inquiry 759.

continued

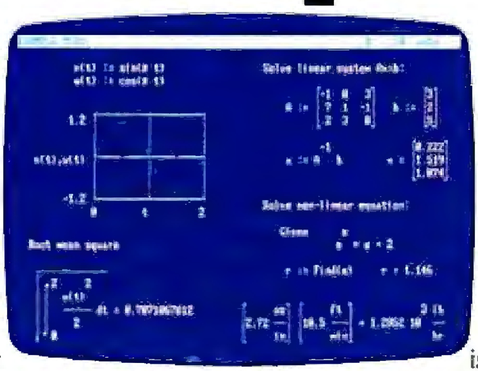


Your pad or ours?

If you perform calculations, the answer is obvious.

MathCAD 2.0.

It's everything you appreciate about working on a scratchpad – simple, free-form math – and more. More speed. More accuracy. More flexibility.



Just define your variables and enter your formulas anywhere on the screen. MathCAD formats your equations as they're typed. Instantly calculates the results. And displays them exactly as you're used to seeing them – in real math notation, as numbers, tables or graphs.

MathCAD is more than an equation solver. Like a scratchpad, it allows you to add text anywhere to support your work, and see and record every step. You can try an unlimited number of what-ifs. And print your entire calculation as an integrated document that anyone can understand.

Plus, MathCAD is loaded with powerful built-in features. In addition to the usual trigonometric and exponential functions, it includes built-in statistical functions, cubic splines, Fourier transforms, and more. It also handles complex numbers and unit conversions in a completely transparent way.

Yet, MathCAD is so easy to learn, you'll be using its full power an hour after you begin.

What more could you ask for? How about the exciting new features we've just added to MathCAD 2.0...

- Built-in equation solver
- Full matrix operations
- Two to four times increase in calculating speed
- Easier full-page text processing
- Auto-scaled plots
- Memory enhancements
- Additional printer and plotter support
- And more.

If you're tired of doing calculations by hand or writing and debugging programs, come on over to our pad. MathCAD. The Electronic Scratchpad.

Call for a detailed spec sheet and the name of a MathCAD dealer near you.
1-800-MathCAD (In MA: 617-577-1017).

Requires IBM PC® or compatible, 512KB RAM, graphics card.
IBM PC® International Business Machines Corporation
MathCAD® MathSoft, Inc.

MathCAD®

MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139

Circle 135 on Reader Service Card

PERIPHERALS

4 Gigabytes on a Write-Once Drive

Toshiba has what it is claiming is the fastest and highest-capacity write-once optical drive available. The drive, called the WM-S500, can store 2 gigabytes of data on each side of a 12-inch write-once optical disk.

The company says the drive's data-transfer rate is from 4 to 8 megabits per second, coupled with an average access time of 150 ms. The WM-S500 operates in a modified-constant-angular-velocity mode where the speed of the disk remains constant (615 rpm) while the data clock varies based on the disk radius. To further speed data transfer, the drive has a 32K-byte buffer.

The drive uses a SCSI interface, which will support up to four WM-S500 drives. You can mount the drive in a standard 19-inch rack. Cartridges load from the front.
Price: $11,495.
Contact: Toshiba America, Disk Products Division, 9740 Irvine Blvd., Irvine, CA 92718, (714) 583-3108.
Inquiry 760.

Compaq's new monitor has a matching video card.

Lower-Cost Sony Multiscan

Designed for all personal computers currently available, from the IBM PC to the PS/2s to the Apple Macintosh II, the CDP-1303 is Sony's latest multiscan monitor that's switchable for either analog or digital input.

With a 13-inch diagonal viewing area and flat-screen technology, the monitor's vertical sync frequency switches automatically to match your computer (50 to 100 Hz). The horizontal scanning range also adjusts automatically over a range of 15.75 to 36 KHz. It's compatible with existing standards from CGA and monochrome mode through the IBM PS/2's 8514A mode.

Though far from a new feature, the Trinitron design retains its unique points of a fine-pitch aperture grill instead of a shadow mask, and a single gun/lens system for optimum color fidelity.

The CDP-1303 weighs 32 pounds and measures 14⅝ by 13 by 16¾ inches. A connecting cable for your particular computer isn't included; and a swivel/tilt stand is optional.
Price: $825.
Contact: Sony Corporation of America, Sony Dr., Park Ridge, NJ 07656, (201) 930-1000.
Inquiry 761.

Mass Storage on VHS Tape

GigaStore is a mass-storage device that uses videotape to store data—up to 2.5 gigabytes on standard T-120 videotape using helical-scan technology. But the unit does more than just store data like a tape-backup device; it fully emulates a 9-track half-inch streaming-tape drive.

According to its maker, GigaStore has an average data-transfer rate of 120K bytes per second. Assuming 32K-byte blocks and a full tape, you'll get an average search time of 3 minutes, and a worst-case time of 6 minutes.

GigaStore uses true read-after-write, coupled with a proprietary error-correction technique. An internal microprocessor controls the interface and all tape positioning. Besides the standard interface for the IBM PC and compatibles, the GigaStore is also available for DEC's QBUS and the UNIBUS.
Price: $5995.
Contact: Digi-Data Corp., 8580 Dorsey Run Rd., Jessup, MD 20794, (301) 498-0200.
Inquiry 762.

18 pins from Seikosha

Seikosha America's SBP-10 printer uses an 18-pin dot-matrix printhead and heavy-duty electromechanics for a combination of high-speed and high-quality results.

With a rated throughput of 250 lines per minute (over 500 cps), the SBP-10 includes a 64K-byte buffer; rear, bottom, and front paper feed; and a built-in cut-sheet-feeder cassette with room for a second (optional) feeder. Also standard are parallel and serial interfaces and a bidirectional push/pull tractor.

You can select print modes from the front panel and see what you've selected on a 16-character by 2-line LCD display. The SBP-10 also accepts up to three Seikosha font cartridges at the same time, with each cartridge holding two fonts. The SBP-10 emulates the standard Epson Escape-P codes, as well as the IBM ProPrinter.
Price: $4495.
Contact: Seikosha America Inc., 1111 MacArthur Blvd., Makwah, NJ 07430, (201) 529-4655.
Inquiry 763.

New Monitors from Compaq

Compaq Computer Corp. has inaugurated new display options for its computers and other IBM PC and AT compatibles. The Compaq Video Graphics Color Monitor and Compaq Video Graphics Monochrome Monitor, when coupled with the Compaq Graphics Controller Board, can display graphics resolutions of up to 640 by 480 pixels and text resolutions of 720 by 400 pixels.

The color monitor, an analog unit with a 14-inch diagonal screen, can display up to 256 simultaneous colors. The monochrome monitor displays colors for up to 64 shades of gray on a 12-inch diagonal white-phosphor screen.

Both monitors include noninterlaced scanning to reduce flickering, diagnostic self-tests, nonglare screens, a tilt-and-swivel base, brightness and contrast controls, and 6-foot power and signal cables.

According to Compaq, when used in an AT-compatible 16-bit slot, the Video Graphics Controller Board runs graphics software up to 50 percent faster than the IBM PS/2 VGA, because it works with 16 bits of video data at a time. The board also fits standard 8-bit slots in PCs and compatibles, but it runs slower.
Price: Color monitor, $699; monochrome monitor, $255; video board, $599.
Contact: Compaq Computer Corp., 20555 FM 149, Houston, TX 77070, (713) 370-0670.
Inquiry 764.

continued

Paradox: the top-rated relational database manager in the world

Source: Software Digest*

Software Digest Rating	Overall Evaluation	Program Name	Version Tested	Ease of Learning	Ease of Use	Error Handling	Performance	Versatility	Memory Requirement	Price
☆☆☆☆	8.7	Paradox	1.1	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	512K	$495
☆☆☆☆	8.2	XDB	1.10	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	320K	$750
☆☆☆	7.6	PowerBase	2.3	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (5.0-6.9)	■ (UNDER 5.0)	384K	$349
☆☆☆	7.0	Open Access II	2.0	■ (5.0-6.9)	■ (5.0-6.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (7.0-9.9)	256K	$395
☆☆☆	7.0	DataEase	2.5/2	■ (7.0-9.9)	■ (7.0-9.9)	■ (UNDER 5.0)	■ (7.0-9.9)	■ (7.0-9.9)	384K	$600
☆☆	6.6	dBASE III PLUS	1.1	■ (5.0-6.9)	■ (5.0-6.9)	■ (7.0-9.9)	■ (7.0-9.9)	■ (5.0-6.9)	384K	$695
☆☆	6.4	R:BASE System V	1.1	■ (5.0-6.9)	■ (5.0-6.9)	■ (7.0-9.9)	■ (UNDER 5.0)	■ (7.0-9.9)	512K	$700

RATINGS KEY
(On a scale of 0 to 10)
Overall Evaluation
☆☆☆☆☆ 9.0 or higher
☆☆☆☆ 8.0 - 8.9
☆☆☆ 7.0 - 7.9
☆☆ 6.0 - 6.9
☆ 5.0 - 5.9
All Other Ratings
■ 7.0 - 9.9
■ 5.0 - 6.9
■ UNDER 5.0

Paradox® is once again the top-rated program, with the latest version scoring even higher than last year's top score." (Software Digest's 1987 Ratings Report is an independent comparative ratings report for selecting IBM PC business software. Ratings Report tests were done by the prestigious National Software Testing Laboratory, Philadelphia, Pennsylvania.)

The Ratings Report message is crystal clear: there is no better relational database manager than Paradox. NSTL tested 12 different programs and amongst other results, discovered that Paradox is 3 times faster than dBASE® and 6 times faster than R:BASE® on a two-file join with subtotals test.†

Paradox combines ease of use with power and sophistication

Even if you're a beginner, Paradox is the only relational database manager that you can take out of the box and begin using right away. Because Paradox employs state-of-the-art artificial intelligence technology, it does almost everything for you—except take itself out of the box.

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

David Schulman, Bendix Aerospace "

Special Offer!

We're making a Special Offer on all three versions of Paradox. Mail proof of purchase, dated between Sept. 15, 1987 and Dec. 15, 1987 and your signed registration form for any of the three, and we'll mail you a $100.00 rebate.** It's that simple!

- Paradox 1.1, suggested retail, $495.00
- Paradox 2.0, suggested retail, $725.00 (each copy of Paradox 2.0 supports one user on a network)
- Paradox Network Pack, suggested retail, $995.00 (each network pack supports up to 6 users on a network)

60-Day Money-Back Guarantee††

PARADOX
by Ansa
A Borland Company

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

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

*Reprinted with permission by Software Digest from its July 1987 Report covering 12 [illegible] programs.

†Test was designed and executed by NSTL. [illegible]

**Rebate requests must be received by Borland no later than February 15, 1988. Mail to Paradox Rebate Department, Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA [illegible]

††If within 60 days of purchase this product does not perform in accordance with our claims, call our customer service department and we will arrange a refund.

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Circle 28 on Reader Service Card (DEALERS: 29)

ADD-INS

10-4 Wireless LAN

If you've been putting off investing in a local-area network because the thought of jungles and jumbles of wires gives you nightmares, Ray-Net Communications Systems may have an answer. Its Ray-LAN is a wireless LAN that communicates among computers at a data rate of 19.2K bps.

Ray-LAN consists of an add-in card that plugs into an expansion slot of any IBM PC or compatible, an RF (radio-frequency) transceiver with antenna, and the company's proprietary communications software, which is compatible with Novell's Advanced NetWare.

The wireless network's transceiver sits next to your computer system and transmits at an output power of 100 milliwatts in the FCC's 72-MHz business band. Under most conditions, the transmission range is about 300 feet. You'll need an FCC license before you can use Ray-LAN, but getting it is a simple matter of filing an application with the commission.

The software included with Ray-LAN uses a proprietary packet technology and includes algorithms for data security. File security is provided by NetWare. You can also bridge Ray-LAN into existing NetWare LANs that run on wired topologies such as Token-Ring or Arc-Net.
Price: $1995 per node.
Contact: Ray-Net Communications Systems Inc., East 12806 Nora Ave., Spokane, WA 99216, (509) 924-2855.
Inquiry 765.

Ray-Net connects computers via radio link.

Add Time to the Model 25

The IBM PS/2 Model 25 computer doesn't have a built-in clock calendar, and Big Blue doesn't sell one. If you don't want to be bothered entering the time and date every time you turn on your computer, you can find a solution in Microsync's PS/2 adapter, which lets you install Microsync's slotless dClock II clock/calendar in the Model 25.

The dClock II with the PS/2 adapter plugs into the back of the Model 25's floppy disk drive and leaves the computer's 1½ slots available for other uses. The company says you can install it in less than 5 minutes. The PS/2 adapter includes a special cable, and software on a 3½-inch disk.
Price: dClock II, $49.95; PS/2 Adapter, $14.95.
Contact: Microsync Inc., 15018 Beltway Dr., Dallas, TX 75244, (214) 788-5198.
Inquiry 766.

TV on Your PC

One of the most unusual add-ins we've seen comes from a Tennessee company named Automated Time Equipment. As its name says, the ATEC PC/TV video graphics card is both a PC graphics card and a television tuner.

On the graphics side, the PC/TV is EGA-, VGA-, CGA-, MDA-, and Hercules-compatible. But when you switch to the TV option, you turn your computer's monitor into a television with tuning and volume adjusted through the keyboard. The board's built-in tuner receives all standard television channels, including UHF and cable.

The PC/TV requires a half-length expansion slot in any IBM PC or compatible. Besides a connector for your monitor, the rear panel of the board has jacks for both an external speaker and an antenna.
Price: $800.
Contact: Automated Time Equipment Corp., 6219 Millbrook Rd., P.O. Box 1903, Brentwood, TN 37027, (615) 377-1156.
Inquiry 767.

Making Music With Your PC

A Boston company, Ad Lib, says its Personal Computer Music System is the first add-in card for the IBM PC and compatibles to provide "instrument-like" sound for music training, composition, and playback. The system consists of the Ad Lib Music Synthesizer Card, Visual Composer software, and a song-selection package named Juke Box.

The Ad Lib Music Synthesizer card is a half-length card that lets you create and play back up to six melodic and five percussive instruments simultaneously. For audio output, the card has a headphone jack and a low-wattage amplifier that will drive a small bookshelf-type speaker.

The Visual Composer software is designed for those with little or no prior music experience. It lets you compose music by selecting an instrument and drawing a line across the screen. The vertical position of the line denotes the pitch of the individual notes, while the horizontal length denotes the duration. The software comes with a variety of preprogrammed sounds and accepts mono MIDI input.
Price: $245.
Contact: Ad Lib, 50 Staniford St., Boston, MA 02114, (800) 463-2686.
Inquiry 768.

continued

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

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

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

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

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

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

The LOGITECH HiREZ Mouse.

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

LOGITECH

Circle 129 on Reader Service Card (DEALERS: 130)

How to pick th

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

Add just $20 more for Logitech's own Plus Software, which assures ease of use with virtually any software, mouse-based or not.

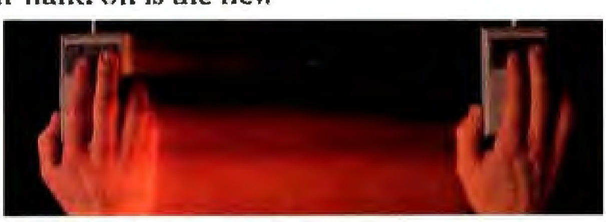
Though most mice out there look pretty much alike, they're not all equal in performance. It pays to be just a little choosy to make sure you end up with the right mouse for your needs.

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

THE HiREZ MOUSE

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

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



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

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

THE SERIES 2 MOUSE

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

e right mouse.

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

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

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

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

THE ALL-PURPOSE MOUSE: SERIAL OR BUS

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

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

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

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

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

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

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

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

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

Name ______________________

Company/Title ______________________

Address ______________________

Phone ______________________

LOGITECH

Circle 131 on Reader Service Card (DEALERS: 132)

ADD-INS

SDI Not Star Wars

In the case of this product from Ariel Corp., "SDI" stands for Signal-to-Disk Interface. SDI is a high-speed device that allows you to accomplish host-independent, real-time, full-bandwidth data acquisition to disk.

SDI consists of an Ariel DSP-16 Data Acquisition Processor along with a high-speed SCSI interface and DSPDISK software. The system lets you record and play back on up to seven high-capacity memory devices.

With SDI, you can do direct-to-disk recording and playback of 16-bit data at sample rates of up to 50 KHz on two channels at the same time. Using the DSPDISK software, you can graphically view and edit the recorded signal. You can mark, zoom, move, repeat, attenuate, and add special effects to the signal.
Price: Starting at $3495.
Contact: Ariel Corp., 110 Greene St., Suite 404, New York, NY 10012, (212) 925-4155.
Inquiry 769.

SDI acquires data directly to disk.

The Telltale Battery

It can be a real pain when the batteries that power the CMOS RAM in your computer suddenly go dead. It normally requires a complete reconfiguration of the system—assuming you can find the floppy disk with your setup program on it. But a new battery monitor can give you an early warning. According to its maker, the Lifeguard monitor can warn you weeks in advance of a dead battery, with a chirp and an LED that flashes every 45 seconds.

Advanced Concepts Research says Lifeguard detects not only the normal ebbing of power from an aging battery, but also low-voltage conditions caused by corrosion or a defective cell.

Lifeguard is palm-size and easy to install. It's compatible with all models of the Macintosh, as well as with the IBM PC AT and compatibles, and all models of the IBM PS/2. On a Macintosh, it replaces the battery-compartment door; on other computers, it mounts to the case with Velcro strips.
Price: $49.95
Contact: Advanced Concepts Research, 6 Pheasant Run, Newtown, PA 18940, (800) 327-8068.
Inquiry 770.


Lifeguard beeps when your battery is terminal.

Organize Those Forms

If you need to keep changing several different continuous forms with your printer, Feed-a-Form is a simple solution to keeping all the paper organized and ready to use.

Using a rack with four sets of acrylic roller/holders, Feed-a-Form holds the end of four different paper stocks above and behind the printer, ready to use. Gravity keeps the rollers down and holds the form until it's needed. An optional take-up basket for completed forms is also available.
Price: $89.95; take-up basket, $39.95.
Contact: Feed-A-Form, 29 Dover Terrace, Westwood, MA 02090, (617) 326-2171.
Inquiry 771.

Get Your Video Together

A product named the VideoShow Professional System from a company named General Parametrics lets you integrate photographic images and computer-generated images in the same picture. The system can produce presentations in video, slides, and overheads.

The system contains an image-capture board, an RGB analog monitor, a video camera, and two newly developed products: Imageprocessor natural image software, and the high-speed Imagelink interface board. The system works with the IBM PC AT and compatibles and requires minimum storage of a 1.2-megabyte floppy disk drive.

The images produced by the VideoShow Professional System are based on a proprietary technology called MacroVision II. This pixel-free graphics display technology creates high-quality synthetic images with up to 5000 colors, and natural images with as many as 100,000 colors. For professional studio applications, the system has a full genlock capability that lets it synchronize with multiple video sources.
Price: $8295.
Contact: General Parametric Corp., 1250 Ninth St., Berkeley, CA 94710, (415) 524-3950.
Inquiry 772.

Another PC Prototype Board

Although there are plenty of prototyping cards available for the IBM PC and compatibles, the CANA group claims its Protosystem I is the first one to have its wirewrap pins organized as buses. The company claims this organization reduces both time and errors in circuit prototyping.

The board includes solder-in-place wirewrap pins, capacitors, and large labels that identify the bus layout. The standard board will hold 72 16-pin ICs. It's available in both a 3-wrap standard pin size that takes up two full-length slots, and a short-pin version that takes up a single slot.

Protosystem I comes with a manual that includes bus addresses and I/O maps. It also describes ways of decoding the address bus and possible problems with timing and bus loading.
Price: Starting at $49.95.
Contact: CANA Group, Suite 402/MS20, 100 Walnut St., Peoria, IL 61602, (309) 674-9009.
Inquiry 773.

continued

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Introducing The Complete Personal Communications™ family: hand scanner, fax and personal voice mail for your PC.

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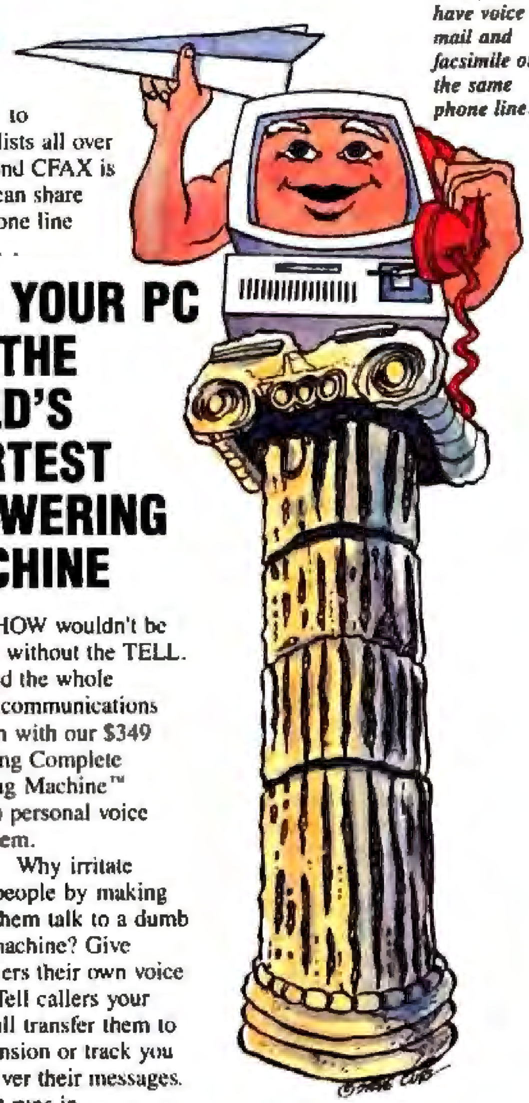

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Circle 45 on Reader Service Card

SOFTWARE • PROGRAMMING

Allegro Common Lisp Updated

Allegro Common Lisp 1.1 for the Mac features background processing under MultiFinder and offers new sample programs, including color QuickDraw. Coral Software reports that bugs found in 1.0 are now fixed.

Allegro Common Lisp is a complete implementation of Common Lisp and features a programmable EMACS-style editor, a stepper, debugger, and a window-based inspector.

Allegro 1.1 runs on any Macintosh, according to Coral.

Price: $600.

Contact: Coral Software, P.O. Box 307, Cambridge, MA 02142, (800) 521-1027; in Massachusetts, (617) 868-7440.

Inquiry 774.

Allegro Common Lisp 1.1 has new sample programs.

Program Tests

WaveTest includes an instrument library generator and an instrument database library with over 50 GPIB (general-purpose interface bus) instruments. Each instrument file contains a lookup table of an instrument's GPIB syntax and commands, the corresponding English-language descriptions, and instructions and setup information. You can also add instruments to the database. The program runs under Microsoft Windows and enables you to generate test programs in an icon-based programming environment. With WaveTest you have three ways of creating programs: flowcharts, modular programming, or BASIC.

The flowchart option lets you see the flow of logic in your program design. You can also print a hard copy. With modular programming, you construct the program step by step by selecting one of 19 module icons. The program executes according to the order in which the icons appear in the program window from left to right and top to bottom. Move them around, and you alter your program. The flowchart and module modes are integrated and your test programs are automatically documented, not only with the flowchart, but with an English-language description of each module as well as instrument setups and command strings.

The Test Program Generator lets you link a series of instrument setups, program modules, operator prompt windows, and formatting windows to create a test program. This is executed as program code. Debugging features such as set breakpoints, single step, trace variables, and monitor GPIB transactions are included.

Wavetek recommends running WaveTest on an IBM PC AT with at least 640K bytes of RAM, a 1.2-megabyte floppy disk drive, a 20-megabyte hard disk drive, an enhanced color display, an EGA card, and a Windows-compatible mouse.

Price: $3990.

Contact: Wavetek San Diego Inc., 9045 Balboa Ave., San Diego, CA 92123, (619) 279-2200.

Inquiry 775.

Access BIOS and DOS Functions from FORTRAN Programs

Extend is a library of subroutines that lets you write interactive graphics applications in FORTRAN, transport mainframe FORTRAN graphics to the PC environment, and access BIOS and DOS functions from FORTRAN programs.

The library's 45 subroutines control direct keyboard entries, PC monitor output, DOS file and directory operations, parallel and serial port I/O, and equipment status. Thirteen graphics subroutines provide solid, dashed, and dotted lines, text strings, and graphics symbols capabilities, allowing variable windows and clipping.

You can display graphic output in CGA, EGA, or VGA, on any Tektronix 4010 device, or translate it to an AutoCAD DXF file or unformatted database file.

Extend supports Microsoft 4.0, Ryan-McFarland, and IBM FORTRAN 77 compilers. It runs on the IBM PC, XT, AT, or compatibles and PS/2s running DOS 2.1 or higher.

Price: $149.

Contact: Design Decisions Inc., P.O.Box 12884, Pittsburgh, PA 15241, (412) 941-4525.

Inquiry 776.

Debugger for 386 Systems

Soft-ICE is a debugging tool that has the capabilities of a hardware debugger, including hardware-level breakpoints, according to Nu-Mega.

With the software installed you pop up a window, set your hard breakpoint, and then return to the soft debugger. As your target program is executing, Soft-ICE recognizes when the breakpoint conditions have been reached and gives control back to your soft debugger.

Soft-ICE lets you set breakpoints on memory-location reads and writes, memory ranges, program execution, port accesses, and interrupts. It gives you memory protection and lets you break out of hung programs even if interrupts are disabled, Nu-Mega reports. The program's status line shows the on-line syntax checking that takes place as you type in commands. Its soft-boot capability lets you debug non-DOS operating systems, loadable device drivers, or self-booting programs. You can also single-step through hardware interrupt-service routines. Another of the program's features is that it works with other debuggers.

The program is not copy-protected, comes on either a 360K-byte or a 720K-byte floppy disk, and includes the debugger, an optional loadable driver, and a demonstration program. It requires a 386 system such as the IBM PS/2 Model 80. It also requires MDA, Hercules, CGA, EGA, VGA, or compatible graphics cards.

Price: $386.

Contact: Nu-Mega Technologies, P.O. Box 7607, Nashua, NH 03060-7607, (603) 888-2386.

Inquiry 777.

continued

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Cadkey Introduces 3-D CAD Package for $495

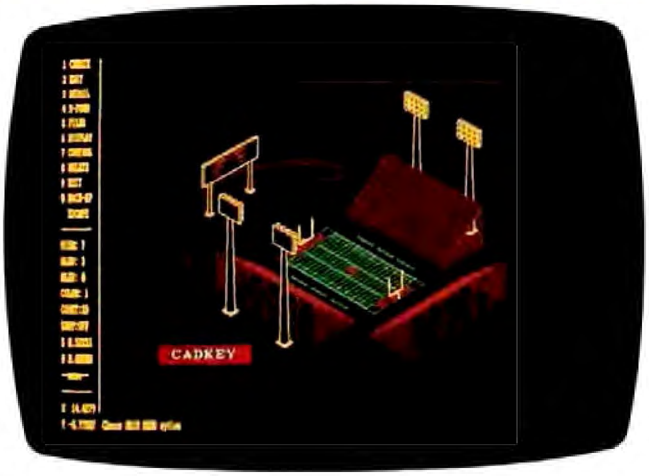
Cadkey 1 is a smaller version of Cadkey 3. You can't link to numerical control and finite element analysis programs like you can with Cadkey 3, but you can transfer Cadkey 1 files through Cadkey 3 to CADL format.

Cadkey 1 complies with ANSI and ISO standards, supports the standard cartesian coordinate system, has 256 levels and 16 colors, and works with high-resolution displays. The program enables you to create a model and inspect it from any distance or position, using its position menu.

A set of eight predefined views include top, front, back, bottom, right, left, isometric, and axonometric. Geometric drawing components include lines, arcs, points, circles, line meshing, fillets, and more.

You can automatically dimension the angle between two lines; the diameter or the radius of a circle or arc; or the horizontal, vertical or parallel dimension between two points. And you have control over the setting or changing of parameters and values for dimensions, labels, or notes. Other features include entity verification and management, and file management.

Cadkey 1 runs on the IBM PC, XT, AT, and compatibles with two floppy disk drives or a hard disk drive, 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a graphics adapter card. Cadkey recommends using a hard disk drive, an EGA card, EGA monitor, 640K bytes of RAM, two serial ports, a parallel port, a mouse or digitizing tablet, and a plotter or printer.
Price: $495.
Contact: Cadkey Division, Micro Control Systems Inc., 27 Hartford Turnpike, Vernon, CT 06066, (203) 647-0220.
Inquiry 778.



A $495 version of Cadkey 3.

Analyzing DC/DC Converters

The Power Electronics Group at the California Institute of Technology has developed a Switching Converter Analysis and Measurement Program (SCAMP). The program is an integrated system for analyzing, designing, and measuring switched-mode pulse-width modulated DC/DC converters and linear circuits.

To begin, you draw a schematic of the desired switching converter, using a mouse and stylized icons from the menu. After you enter the values for the elements of the schematic, SCAMP computes poles and zeros of specified transfer functions and offers a choice of Bode or Nyquist frequency-response plots.

SCAMP is made up of two preprocessor modules, GIM (Graphics Input Module) and NIP (Nodal Description Input Program), and eight program modules. GIM takes the schematic and values as inputs and generates a net list file in the form of a nodal description of the circuit; NIP converts this nodal description of the circuit into state-space matrices and vectors, which then become inputs to the computational program modules of SCAMP.

SCAMP employs state-space averaging to calculate the small-signal frequency response of the converter circuit. Outputs include poles, zeros, and frequency responses.

The program requires an IBM PC, XT, AT, or compatible with at least 640K bytes of RAM, a Microsoft Mouse, a CGA or EGA board, and a printer.
Price: $1500; program with site license, $5000; additional manuals, $25.
Contact: California Institute of Technology, Power Electronics Group, Mail Station 116-81, Pasadena, CA 91125, (818) 356-4820.
Inquiry 779.

An Expert Sample

With answers based on user responses, Ex-Sample determines the optimum size of a research sample, what type of analysis to perform, and how to interpret the results. The program includes procedures to determine the sample size required to perform a wide range of statistical analyses including one- and two-sample comparisons of mean and proportions; one-way analysis of variance, bivariate, and multivariate contingency tables; regression and path analysis; comparisons of two correlations; log-linear models; and factor analysis.

The program adjusts the size downward to reflect response rates, contamination, exclusions, and other factors. It then compares the resulting sample size with sizes required to perform specific analyses. The program outputs a report in ASCII, describing sample size recommendations.

Some of the program's features include a change and rerun capability for sensitivity analyses, references and notes documenting procedure used, and clarifications and explanations or questions.

Ex-Sample runs on the IBM PC and compatibles with at least 384K bytes of RAM and one floppy disk drive. The Idea Works recommends two floppy disk drives or a hard disk drive.
Price: $95.
Contact: The Idea Works Inc., 100 West Briarwood, Columbia, MO 65203, (314) 445-4554.
Inquiry 780.

Scientific Calculator

The ELI-41 emulates the HP-41, enabling you to run familiar programs and perform calculations on your IBM PC, XT, AT, or compatible using HP-41 commands. It provides 15-digit precision and lets you store and retrieve programs and the results of your computations.

ELI-41 displays all data registers, flags, and the stack and offers you a hard copy of data and results.

You can pop up ELI-41 independently and input data from another applications program. The calculator supports the 8087/80287 math coprocessor chip. HP-41 user-solution libraries are available on disk for use with ELI-41.

ELI-41 runs on the IBM PC with at least 128K bytes of RAM.
Price: $99.95.
Contact: Eclipse Logic Inc., P.O. Box 2003, Huntington Park, CA 90255-1303, (213) 569-6020.
Inquiry 781.

continued

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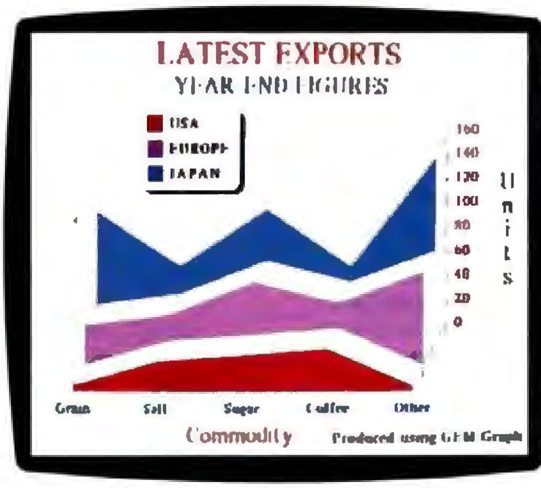

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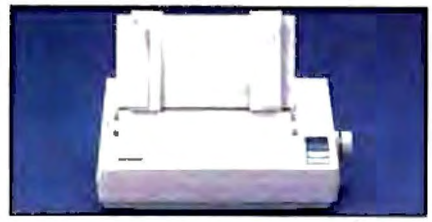

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SOFTWARE • BUSINESS

Personal Information Manager

Info-XL, Valor's personal information manager, organizes text and structured data. It features data-management facilities, import/export capabilities, free-form text processing, and data links.

Six menu-driven windows appear on-screen, with the Manager window serving as your interface window. The other five windows include Records, for entering structured data or records; Comments, which lets you enter free-form text and perform search-and-replace operations; Daily and Monthly Scheduler windows, for cross-indexing events and dates; and the Search window, which shows the results of your queries. While you work in one window, the others reflect the files, dates, and information. You can also switch among the six windows.

Info-XL runs on the IBM PC or compatibles with at least 384K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher.
Price: $265.
Contact: Valor Software Corp., 1700 Don Ave., San Jose, CA 95124, (408) 978-3044.
Inquiry 782.

Info-XL organizes text and structured data in six windows.

Small Business Accounting on the Macintosh

Simply Accounting includes General Ledger, Payables, Receivables, Payroll, Inventory, and Job Cost modules on one disk. It takes advantage of the Macintosh interface by displaying invoices, checks, and other accounting documents on-screen. Sample financial records are included to get you started.

The General Ledger lets you produce reports on balance sheets, income statements, trial balances, charts of accounts, all journals, or all ledgers. The program produces audit trails and lets you handle accounts up to $20 million.

The program runs on Macs with 1 megabyte of memory, at least 800K bytes of RAM, and 128K bytes of ROM. It is not copy-protected and supports AppleShare and Multi-Finder. Bedford supplies telephone support for a fee.
Price: $449.
Contact: Bedford Software Ltd., Suite 201, 4180 Lougheed Highway, Burnaby, B.C. V5C 6A7, Canada, (604) 294-2394.
Inquiry 783.

The Daily Sales Routine

First Phase calls Daily Routine a sales activity-management software program. It has a name and address file, call and time reports, expense and mileage reports, a daily agenda, a sales-call note screen, a quotation screen, and a quick-memo word processor.

You can add names and addresses to the name and address file with codes, so the program groups them for faster retrieval. Then when you type a memo, you can pull the name and address from the file, and even have an envelope or mailing label printed.

The sales-call note screen is used as the basis for creating many of Daily Routine's reports. On the screen you enter information on quotations you've given, agenda items, and company history files. In the quotations file you can view all the quotes you've made, or just focus on one competitor. The program totals the quotes for an activity period that you specify. The company history feature lets you enter the name of the company, and it returns information on your contacts there, orders made, deliveries completed, and so on.

The quick-memo feature has limited word-processing features. You can write up to 14 lines of code, print or save them, and print an envelope label. The program will store up to 64 memos.

A pop-up calendar shows the current month, or you can page backward or forward to display past or future months. If your system has a clock/calendar, the program will display the date at the top of your daily screens.

Daily Routine runs on the IBM PC and compatibles with at least 256K bytes of RAM. You can use a monochrome or color monitor.
Price: $175.
Contact: First Phase Inc., P.O. Box 4504, Greensboro, NC 27404, (919) 855-8858.
Inquiry 784.

Hypertext Word Processing

Black Magic, a hypertext word processor, links your objects or thoughts to related thoughts, allowing you to build nonsequentially organized documents, or hypertext. Black Magic also allows you to integrate text and graphics.

To read documents created with Black Magic, you can use Ntergaid's reader programs developed for CGA, EGA, and Hercules modes. The company reports that it is developing reader programs for the Mac, Amiga, and Atari ST; and the reader programs are public domain.

Black Magic comes with sample files and a terminate-and-stay-resident screen capturing utility. It runs on the IBM PC, XT, AT, and compatibles with EGA graphics.
Price: $150.
Contact: Ntergaid, 955 Connecticut Ave., Bridgeport, CT 06607, (203) 368-0632.
Inquiry 785.

Designing a Schedule

Schedule View is a project manager that helps you design your schedule on-screen using commands such as block copy, move, or erase. You can perform basic calculations and print standard reports. The Vaughn Group asserts that, unlike other project managers, Schedule View creates the schedule graphically.

The program runs on the IBM PC, XT, AT, and compatibles with at least 640K bytes of RAM, a 10-megabyte hard disk drive, and a floppy disk drive.
Price: $495.
Contact: The Vaughn Group Inc., 2915 LBJ Freeway, Suite 161-106, Dallas, TX 75234, (214) 484-0702.
Inquiry 786.

continued

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

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

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

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

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

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Database Accesses One Record a Second

GEN-AI can search through databases of 40,000 records or more, accessing one per second, according to Logirex. You can enter records as sentences of any length, and you don't have to predefine how many characters per field or how many fields per record. GEN-AI can search on any character string within your data, even if it's embedded in text, Logirex reports.

The program has an English-based parser that uses a synonym facility to understand the commands you enter. For instance, you could enter `Store`, `Remember`, `Keep`, or `Add`, and the parser will understand them all to mean `Enter`. A built-in text editor lets you insert correspondence into your database, include ASCII printer codes, and format documents. You can also use it to attach notes to records in the database. It also includes a spelling checker.

GEN-AI provides facilities for you to compute numeric and date arithmetic and Boolean relations, and adjust significant digits.

Using the program's graphics capabilities, you can create bar charts and graphs. A Form-doer lets you design your own database forms on-screen using cursor-control keys and ASCII characters. The program queries you for definitions of each element. Then the Form-doer performs checks and validations on data.

Other features of GEN-AI include a security system, which enables you to use the program in stand-alone mode, if you prefer. The program lets you recall up to 32 of the last screens, which it maintains in a continuous loop. At any time, you can save a screen in the editing buffer and store it as a data record. An Undo command will get rid of your last operation, what you did in an entire session, or all your work from one day.

GEN-AI searches character strings in up to 40,000 records.

The program comes on three 360K-byte disks. To run it, you need at least 2 megabytes of hard disk space and at least 330K bytes of RAM. It runs under MS-DOS 2.0 or higher. A multiuser version will run with OS/2.
Price: $595. (Multiuser OS/2 version will sell for $795.)
Contact: Logirex Inc., 20863 Stevens Creek Blvd., Suite 330, Cupertino, CA 95014-2187, (408) 257-5203.
Inquiry 787.

Fill Out Forms with Finesse

Using Fill & File, you create on-screen a duplicate of the form you have to fill out. You can import information from dBASE, ASCII, Lotus 1-2-3, or other files, or you can tab from blank to blank and fill in the form yourself.

Pull-down menus assist you in designing the form. You have choices of solid, bold, or dotted lines; text sizes; and automatic box drawing. Text-editing capabilities let you write over text, wrap words, underline, boldface, center, justify, and reformat paragraphs. You can also use color and graphic symbols.

Fill & File can perform math functions and total columns. You can export DOS-compatible extended ASCII files from Fill & File. The program also lets you save data to data files, rather than to just the form file.

The program runs on the IBM PC and compatibles with at least 512K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. It doesn't require a graphics board, FormWorx reports.
Price: $149.
Contact: FormWorx Corp., Reservoir Place, 1601 Trapelo Rd., Waltham, MA 02154, (617) 890-4499.
Inquiry 788.

Need Help Making a Decision?

Using a technique that breaks possible solutions to a problem into a series of pairs, BestChoice helps you make decisions by statistically rating and ranking the superior choice. The pairs can be evaluated by one to five decision makers using up to five criteria. Blank questionnaires for each of the five criteria are printed.

The program outputs a Final Result report with the name of the problem and the decision makers involved. It shows each criterion and its weighted factor.

BestChoice requires an IBM PC with at least 128K bytes of RAM. You can use a color or a monochrome monitor.
Price: $49.
Contact: Sterling Castle Software, 702 Washington St., Suite 174, Marina del Rey, CA 90292, (800) 722-7853; in California, (213) 306-3020.
Inquiry 789.

Time Series Forecasting

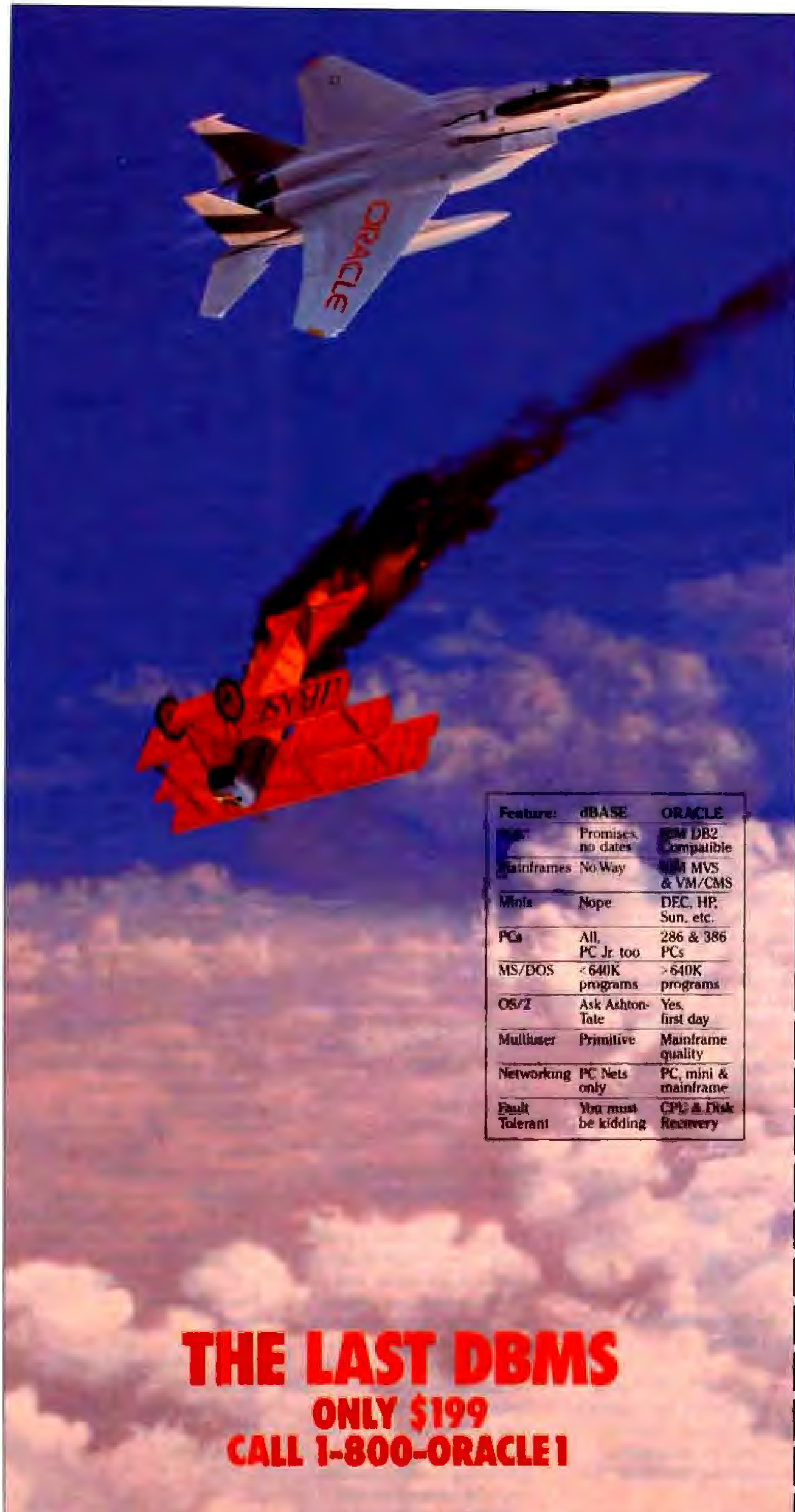
Wisard Forecaster, a Lotus 1-2-3 add-in, is based on a technique that runs four forecasts and combines them for a final forecast. You can use it to project future trends, levels, and seasonality, based on the historical data stored in your 1-2-3 spreadsheet. The program automatically determines the seasonal pattern, calculating the season length and seasonal factor.

To create a forecast you define up to 12 input ranges for one time series by pointing to or specifying the cell number or range name. Each range can be a row, column, or block of data. You then set up your requirements, specifying what kind of data you have and how many forecasts you want. After telling Wisard where to put the output, you start the forecasting process. The program performs 47 passes over the data and up to 250,000 floating-point calculations.

You have a variety of output options, including different kinds of reports and graphs.

The Wisard Forecaster add-in runs on the IBM PC, XT, AT, and compatibles with at least 640K bytes of RAM, Lotus 1-2-3 version 2.0 or higher, and MS-DOS or PC-DOS 2.0 or higher. The program also supports math coprocessors.
Price: $99.
Contact: Wisard Software Co., 333 Main St., P.O. Box 19730, Green Bay, WI 54307-9730, (414) 436-2341.
Inquiry 790.

continued



Feature:	dBASE	ORACLE
[illegible]	Promises, no dates	[illegible] DB2 Compatible
Mainframes	No Way	[illegible] MVS & VM/CMS
Minis	Nope	DEC, HP, Sun, etc.
PCs	All, PC Jr. too	286 & 386 PCs
MS/DOS	<640K programs	>640K programs
OS/2	Ask Ashton-Tate	Yes, first day
Multiuser	Primitive	Mainframe quality
Networking	PC Nets only	PC, mini & mainframe
Fault Tolerant	You must be kidding	CPU & Disk Recovery

[1] Revenues doubled in 9 of Oracle's 10 years. [2] Sales rate over $200 million in current fiscal year. [3] For PC development use only. Requires a 286/386 PC plus 1-Mbyte extended memory. Offer valid only in US & Canada. © 1987 by Oracle Corp. ORACLE® is a reg. trademark of Oracle Corp. dBASE is a reg. trademark of Ashton-Tate. Microsoft & IBM own numerous reg. trademarks. TRBA

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SOFTWARE • OTHER

Draw It Again, Sam

Aba Software's Draw It Again, Sam is an object-oriented drawing program for the Macintosh that offers graphics and text libraries that you can access by clicking on icons. You can add up to 500 objects or groups of objects to libraries in this way as well.

A layering capability lets you divide a drawing into as many as 10 layers. You can use layers with colors to produce color separations or to extend one drawing into an animation series. Drawing modes included with the program are opaque, clear, invert, and erase. Aba Software reports that you can use colors on all Macintosh models, and if you don't have a color monitor, you can use an Imagewriter II or other color printer to see the colors.
Price: $150.
Contact: Aba Software Inc., P.O. Box 850, 2 Davis Ave., Frazer, PA 19355, (215) 640-4770.
Inquiry 791.

Draw It Again, Sam produces color separations.

Total Word

Lifetree Software calls Total Word a new generation of document processing. It offers word processing, graphics capture, over 400 scientific and technical symbols, and a selection of printer drivers and HP LaserJet fonts.

The word processor has an editorial revision feature that lets you share a document with others, make revisions and changes, and attach comments. Other features include automatic index, outline, footnote, and table of contents generation. Also included is a 300,000-word thesaurus and a 170,000-word spelling dictionary.

Some of the desktop-publishing features include box drawing and the ability to produce columns of text and graphics. You can also incorporate graphics from any program, Lifetree reports. The program, however, does not contain page-layout features, kerning, the ability to wrap text around graphics, or high-resolution graphics.

To run Total Word, you need an IBM PC, XT, AT, or compatible with a floppy disk drive or hard disk drive, at least 480K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and an 80-character monochrome or color display. Total Word also runs on the IBM PS/2s. To display special scientific characters, you need an EGA, VGA, or MCGA adapter or equivalent or a Hercules Graphics Card Plus with RAMFont. Total Word also supports PostScript and works with Volkswriter 3 and Volkswriter Deluxe Plus.
Price: $495.
Contact: Lifetree Software Inc., 411 Pacific St., Monterey, CA 93940, (408) 373-4718.
Inquiry 792.

Tree Structure Your Mac Files

MacTree is a hard disk organizer that creates a tree directory of file-folder icons and operates with all standard Mac interfaces. You use the mouse to locate, open, close, or move files. When you move or change a file, it updates the entire tree structure. To reach a file or subfile, you move yonr mouse to the icon and double-click. You can view all the subfiles in that library or ask the computer to create a new icon tree displaying that folder. You can create up to 255 sublevel branches with MacTree.

MacTree runs on the Mac 512E, Plus, SE, and II. Software Research reports that it supports any screen size.
Price: $69.95.
Contact: Software Research Technologies, 22910 Mill Creek Dr., Suite B, Laguna Hills, CA 92653, (714) 472-0474.
Inquiry 793.

Pulling Knowledge from Databases

IXL: The Machine Learning System reads databases in dBASE III, Lotus, and ASCII formats and outputs rules based on statistical and artificial intelligence techniques. The rules give you information on relationships and knowledge that you may not have known was in your database. Without any preprogramming to analyze a database, the system can deal with inexact or omitted data, according to IntelligenceWare. You can define concepts, rules, and frames, and you can specify your own level of acceptable error.

IXL runs on the IBM PC, XT, AT, or compatibles with at least 512K bytes of RAM and a hard disk drive.
Price: $490.
Contact: IntelligenceWare Inc., 9800 South Sepulveda Blvd., Suite 730, Los Angeles, CA 90045, (213) 417-8896.
Inquiry 794.

Music Notation with a Graphic Twist

Music Publisher, a Macintosh music scoring and composition program, is available in two versions: one for individual composers and musicians and one for commercial music publishers.

The program sets up a computer screen as an electronic paste-up board, which you combine with design aids, typographical standards, and page-layout principles.

One of the features of the program alerts you if you enter incorrect notation. Another feature lets you listen to your score through external speakers.

Music Publisher accepts music notation from a MIDI source and can output to PostScript-compatible laser printers. It also supplies its own PostScript-compatible music font. A note and lyric processor lets you integrate lyrics and music in a single pass. The program also accommodates orchestral and other scoring requirements.

Graphic Notes reports that Music Publisher runs on all Macs.
Price: $595.
Contact: Graphic Notes Inc., 2-1645 East Cliff Dr., Suite 29, Santa Cruz, CA 95062, (408) 476-0147.
Inquiry 795.

Mac II power for the SE:

Once you try an accelerated SE, you won't want to go back. Prodigy SE™ by Levco gives you the highest performance, true Mac™II and SE compatibility, and *confidence* that your system will expand properly. Here's how:

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The Prodigy SE can expand to 4 Mb of RAM now (with future expansion up to 32 Mb). And, like the Mac II, Prodigy SE includes a socket for the PMMU chip that is essential for Apple's® upcoming A/UX™. Boards without the PMMU lock you out of Apple's next-generation software.

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REGIONAL SECTION

PACIFIC COAST

Multiscanning Monitor

Thomson's 4570 is a 14-inch color monitor that is compatible with CGA, EGA, extended EGA, and PGC standards. The multiscanning monitor provides a 0.31 millimeter dot pitch and a maximum resolution of 640 by 480.

The 4570 includes a built-in tilt-and-swivel base and a front panel with brightness, contrast, input type, and power controls. With the color selection button you can switch between green, amber, and blue text.

Price: $695.

Contact: Thomson Information Systems Corp., 5731 West Slauson Ave., Suite 111, Culver City, CA 90230, (800) 325-0464; in California, (800) 237-9483.

Inquiry 814.

The 4570 monitor provides a 640- by 480-pixel display.

80386 Supports 33 Users

Acer's SYS-32/20 supports up to 33 users with its 20-MHz 80386 microprocessor and SCO Xenix V/386 operating system. It includes 4 megabytes of zero-wait-state RAM on the motherboard, and a 68000 microprocessor with buffer memory to support terminal I/O activity.

The system also includes one 32-bit, five 16-bit, and two 8-bit expansion slots; a 14-inch monochrome monitor; a 101-style keyboard, and a graphics card.

Price: $6995.

Contact: Acer Technologies Corp., 401 Charcot Ave., San Jose, CA 95131, (408) 922-0333.

Inquiry 815.

continued

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Smalltalk with Color, Graphics

Smalltalk-AT Plus and Color Plus are enhanced versions of Softsmarts' Smalltalk-80. Each provides a compiler, interactive debugger, and inspectors.

The programs feature bit-mapped graphics, windows, and text and graphics editors. Smalltalk-AT Plus also features user-defined primitives and asynchronous communications support. Smalltalk-AT Color Plus adds color capabilities, providing up to 16 colors from a palette of 256.

Smalltalk-AT Plus and Smalltalk-AT Color Plus run on the IBM PC AT and compatibles with 1.5 megabytes of RAM and a three-button mouse. A hard disk drive is recommended.
Price: Smalltalk-AT Plus, $995; Smalltalk-AT Color Plus, $1295.
Contact: Softsmarts Inc., 299 California Ave., Suite 205, Palo Alto, CA 94306, (415) 327-8100.
Inquiry 816.

80386 Operating System

VM/386 enables you to run multiple programs on an 80386-based microcomputer by using the chip's virtual 8086 mode. It creates virtual machines, each running under a different operating system. Each virtual machine can also have its own terminate-and-stay-resident programs.

VM/386 runs on 80386-based microcomputers with at least 2 megabytes of RAM.
Price: $245.
Contact: IGC, 4800 Great America Pkwy., Santa Clara, CA 95054, (408) 986-8373.
Inquiry 817.

Epson's LQ-500

This under-$500 24-pin dot-matrix printer features a print speed of 180 characters per second (cps) in draft mode and 60 cps in letter-quality mode. It includes a friction-feed and pull tractor, built-in Roman and Sans Serif fonts, and automatic single-sheet loading.

Other features include bidirectional printing in both text and graphics modes, an 8K byte buffer, a Centronics parallel interface, and shadow and outline printing modes.

Options for the LQ-500 include font modules, a single-bin cut-sheet feeder, 81xx interface cards, and software for Microsoft Windows.

The LQ-500 measures 5½ by 15½ by 12½ inches and weighs 15 pounds.
Price: $499.
Contact: Epson America Inc., 2780 Lomita Blvd., Torrance, CA 90505, (800) 421-5426; in California, (213) 539-9140.
Inquiry 818.

Roland's Rhythm Machine

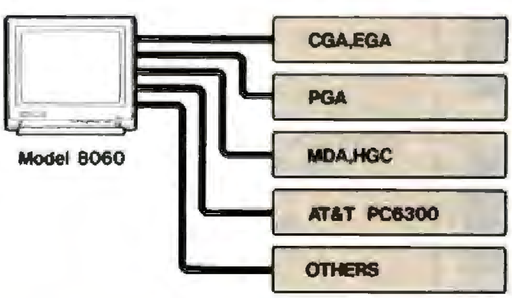
The TR-626 is a rhythm machine that features 30 tunable sound sources and eight outputs. Drum sounds include a five-piece drum set with two variations per drum, Latin percussion sounds, and cymbals.

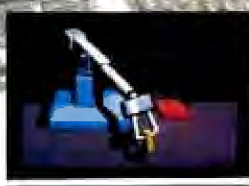
The TR-626 provides a memory for 48 preset and 48 programmable rhythm patterns. It includes MIDI functions, a song position pointer, and tape sync.
Price: $495.
Contact: RolandCorp US, 7200 Dominion Circle, Los Angeles, CA 90040-3647, (213) 685-5141.
Inquiry 819.

NANAO MODEL 8060

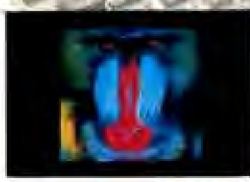
the multi-scan frequency monitor for multi-scan graphics adapters.

Model 8060, the multi-scan frequency monitor, gives you great versatility, and enables you to be flexible with different kinds of graphics adapters and personal computers which you have now or may purchase in the future. This is just one advantage of the multi-scan frequency system, but its greatest advantage is the flexibility it provides with the newest graphics adapters, which can output a wide variety of resolution modes in different scan frequencies. Don't miss this opportunity to increase productivity in your office by taking full advantage of the most advanced technology available today.





PGA



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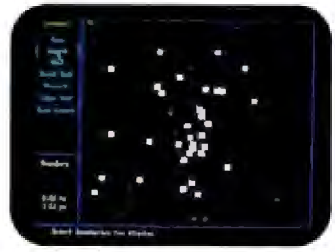
Database. For any point, call to the screen all the data behind the point. You specify the fields. Or use dBASE III files.

Label Points. Pick any field in your database to label points.

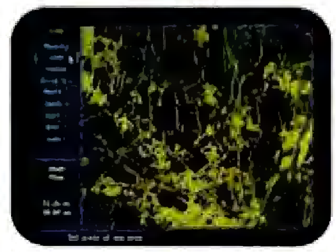


Boundaries. Town, county, zip available. Or draw your own—e.g., sales territories—and display the data within the boundaries.

Thematic. Shade boundaries—ours or yours—based on fields you select from your database, or the number of points found inside the boundaries.

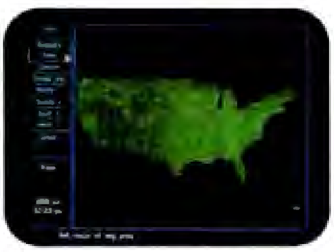
Magnify. As close as 52 ft. across the screen. For dense databases or to see details.

Ultra Dense. For multiple occurrences at a single point, display a count of all the records behind the point.

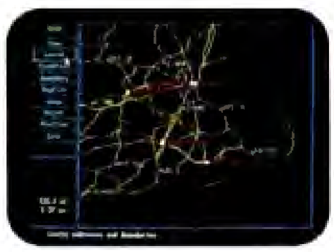


Zoom Out. As far as 5,000 miles! See your data across your city or the entire U.S.

The U.S. Assign data to state boundaries. States may be automatically shaded based on data within.



Counties By State. The boundaries are already available. Simply load your existing data.



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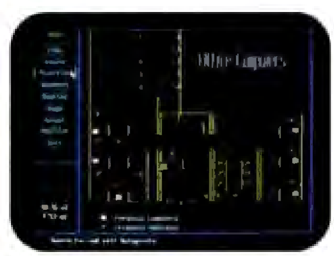

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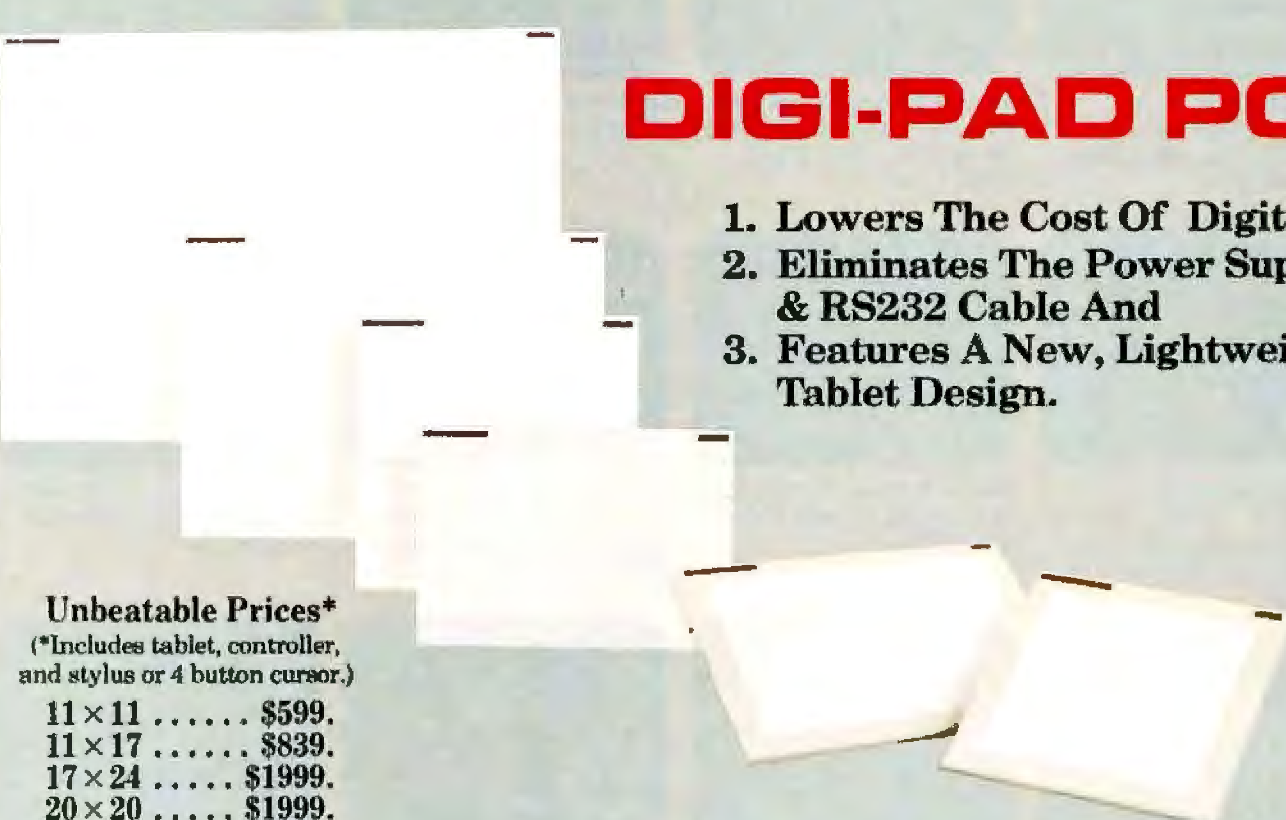

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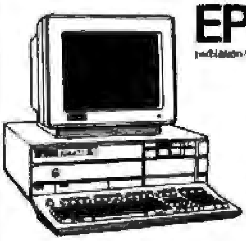

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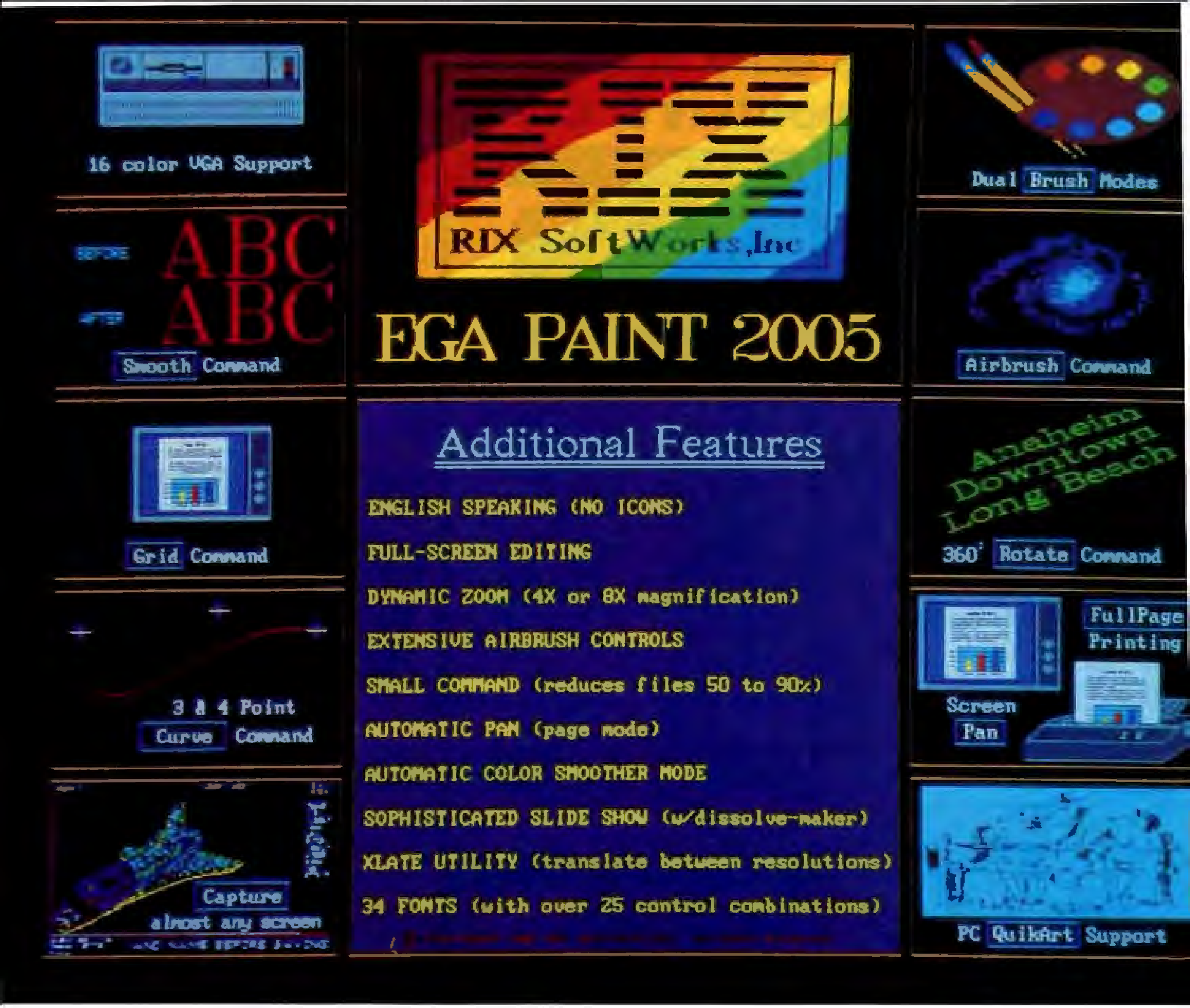

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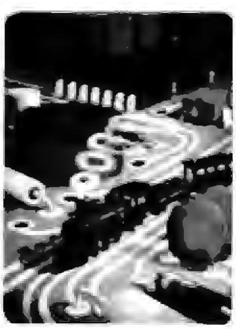
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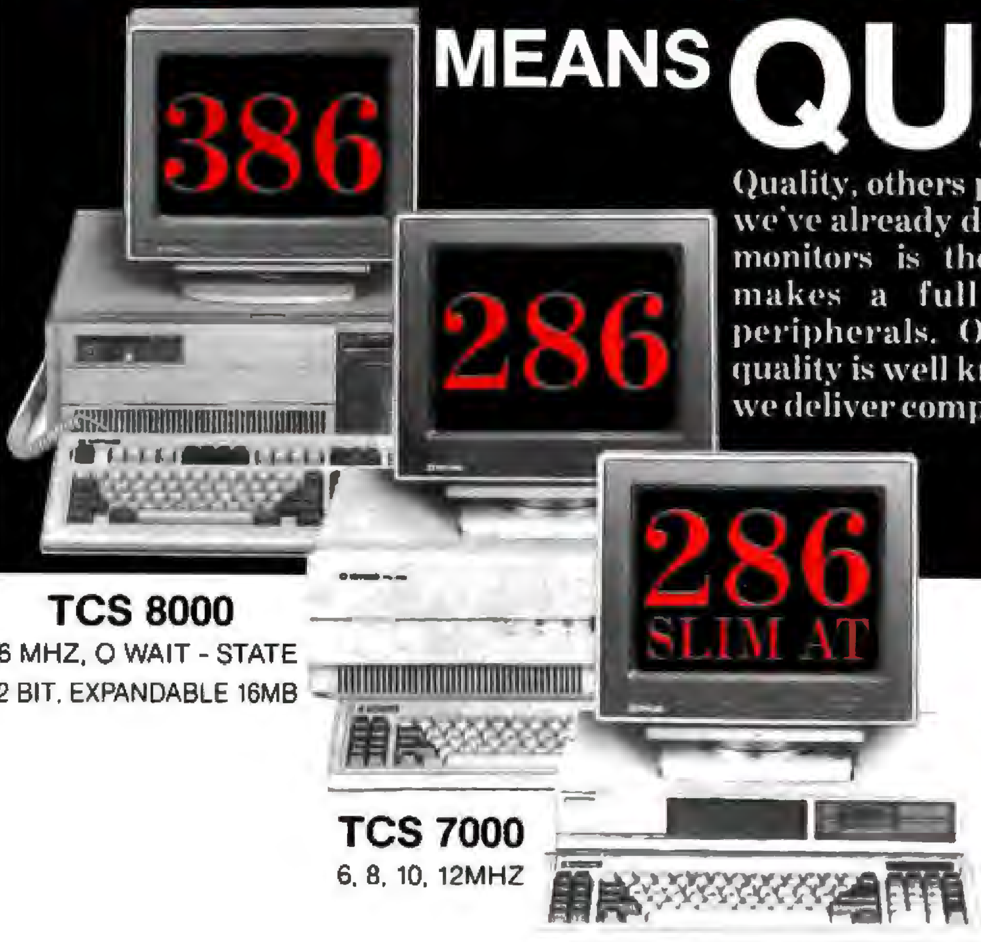

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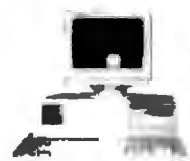

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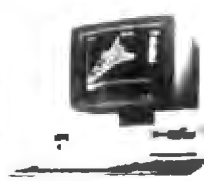

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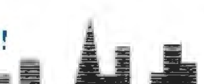

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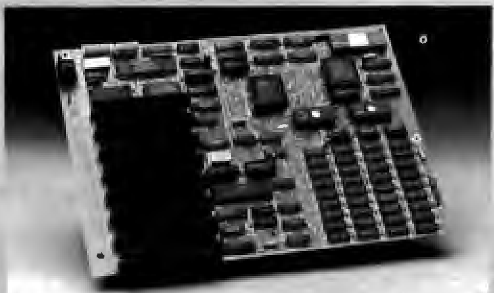

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Lotus 1-2-3/Hal/Metro	$309/120/85
Symphony	410
Framework 2	385
D Base III+	395
WordPerfect 4.2	219
Microsoft Windows	69
Xerox Venture Publisher	499
Aldus Pagemaker	465
Multimate Advantage II	440
Ability/Enrich by Migent	LOW

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Epson LQ800/1000	489/649
Epson LX86/FX85	199/349
Epson EX800/1000	496/649
Epson LQ2500	1099
Epson FX86E/FX286E	359/475
IBM Proprinter II	399
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IBM Color Monitor 8513 PS/2	$512
IBM Mono Monitor 8503 PS/2	200
IBM Color Monitor 8512/8519	485/1196
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Circle 477 on Reader Service Card

SHORT TAKES

BYTE editors offer hands-on views of new products.

Share Your IBM PC Hard Disk Drive with a Mac

I can't help it; I'm hooked on **QuickShare**. I shouldn't be, because it costs too much: $465 gets you a half-size IBM PC board, some software, and a cable. But the convenience this combination unleashes almost makes it worthwhile, particularly if you spend equal parts of your time on an IBM PC and a Macintosh Plus (as I do).

QuickShare's half-size PC board is a SCSI interface that you plug into your PC, XT, or AT and into the SCSI port on the back of your Mac Plus via the cable included. Your Mac can then use your PC's hard disk drive as a hard disk of its own. QuickShare accomplishes this with a terminate-and-stay-resident (TSR) program, whose name you add to your AUTOEXEC.BAT file so that it installs itself when you boot your PC (the upshot of this is that you *must* boot your PC before booting your Mac, or the Mac won't see the QuickShare interface).

It isn't as perfect as it sounds. The Mac does not access the PC's entire hard disk as a Mac drive; rather, you use an installation program to create a special file, and this file is what the Mac sees as its hard disk volume. Consequently, to send files between the PC-DOS universe and the Macintosh universe, you have to use QuickShare's PCTransfer program.

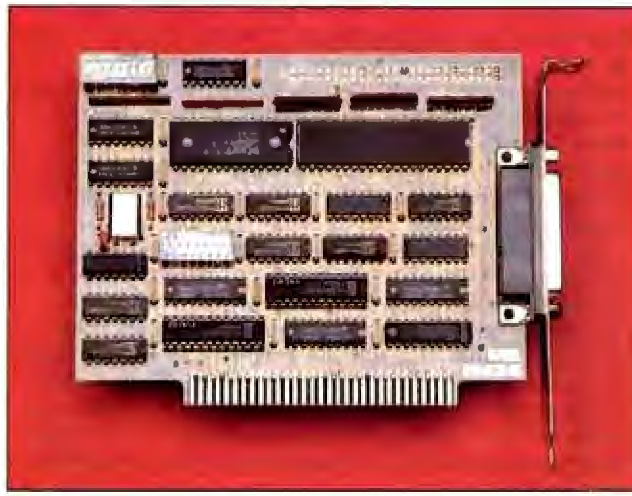
I tested QuickShare on an ITT XTRA (a 6-MHz AT clone) with 512K bytes of RAM and a 10-megabyte hard disk drive running PC-DOS 3.1, hooked to a Mac Plus with 2 megabytes of RAM and an Apple HD20 hard disk drive (20 megabytes) running MultiFinder 6.0 and System 4.2.

I used the system in my day-to-day office activities for nearly 4 weeks with no crashes (most of my time on the Mac was spent in MacWrite and Edit). I found I could lock the system up by using TYPE on a large file or by hitting Control-S in the midst of output (both on the PC side); the Mac would wait quietly until whatever logjam on the PC had cleared up, then continue as though nothing had happened. If I were in the middle of editing a document on the PC in WordStar 4.0, however, the Mac had no problem accessing files on the PC.

Finally, I ran the Fileio benchmark from the Mac Plus on both the HD20 and the QuickShare volume (I ran programs on both machines to remove any fragmentation that might confuse the results). Oddly enough, the HD20 completed the benchmark in 155 seconds, while the QuickShare volume took about 202 seconds. Not very impressive, especially when you consider that the HD20 is talking through the floppy port, while QuickShare communicates through the SCSI.

QuickShare makes file transfer between the Macintosh and IBM PC painless. If you've already got a PC with a hard disk drive and you have a Mac Plus without one, QuickShare *almost* makes sense; you're going to pay around $475 for a Macintosh hard disk drive anyway.

—Rick Grehan



The Facts:
QuickShare
$465

Requirements:
IBM PC, XT, or AT running PC-DOS 3.0 or higher; Apple Macintosh Plus, 512E (with SCSI option), or Mac II.

Compatible Systems Corp.
P.O. Drawer 17220
Boulder, CO 80308
(303) 444-9532
Inquiry 853.

The Personal Information Manager from Lotus

Agenda is a free-form database manager with artificial intelligence (AI) capabilities. You begin by entering "items"—names, telephone numbers, addresses, and other text data up to 350 characters long. (You can also attach "notes" up to 10K bytes long to any item.)

Items are assigned to "categories." Here's where the magic—and for some, the madness—of Agenda comes in. You can assign an item to several categories and attach conditions to categories so that, for example, the program automatically inserts items into the correct category. You can look at your database in any of several "views," and information that you add to an item in one view automatically appears in other views. Keeping track of those categories and views is where the madness comes in.

Let me give you a practical example. I worked out my own system for logging in books for BYTE book reviews: choosing an appropriate reviewer, keeping track of when the review is

continued

completed, and so on. Transferring that task to Agenda seemed like a natural application.

Problem: Agenda lets you import data from your current text files, but the process (at least as explained by the preliminary documentation that I received) is not for the fainthearted. (I previewed an alpha release of Agenda. Lotus promises revised and improved documentation by the time Agenda is released.) I was finally able to import a list of the books currently in house. I then created a category called Subject and began entering a keyword for each book—Macintosh, Lisp, MS-DOS, Unix, and so on. Agenda immediately started showing off its AI smarts: The first book I entered was about the Macintosh. The next time I ran across a book about the Mac, I merely had to type *M* and Agenda beeped to tell me that it already had a possible name—which it displayed—in its Subject list. I hit "Enter," and Agenda popped in the full name.

You might have to type two or three letters before Agenda can figure out what you're after, but you'll still save a lot of typing with this feature. In fact, if the keyword was in the title, Agenda inserted it into the Subject category automatically. Now, I'd like to be able to figure out how to enter each new book as I receive it and have Agenda provide me with a list of appropriate reviewers. I'm pretty sure the program can do that, but I haven't been able to figure out how. Lotus says that it is redesigning parts of the user interface to make things easier to understand.

Agenda has a number of other neat tricks. If you create a Date category and type "today," the program will insert the correct date; the same for "yesterday," "tomorrow," and "a week from Friday." You can also assign to categories "actions," such as "discard any item after it is a week old." Agenda automatically saves your data as you are working. Its menus are nested, much like Lotus 1-2-3's; it lets you create macros; and it lets you print reports in a variety of formats.

With all these features, learning to use Agenda is not a trivial task. The folks at Lotus liken the difficulty of comprehending this new product to the confusion that attended the birth of the electronic spreadsheet. Unfortunately, Agenda doesn't have the spreadsheet metaphor to help you understand it. Plan to spend a fair bit of time getting used to the program, and even more time converting your current method of organizing tasks to Agenda. Like me, you may not become a true believer right away, but you may see enough to make you stick with it.

—Ken Sheldon

The Facts:
Agenda
$395

Requirements:
IBM PC, XT, AT, or PS/2.

Lotus Development Corp.
55 Cambridge Parkway
Cambridge, MA 02142
(617) 577-8500.
Inquiry 859.

Word 4.0 Revised with New User Interface and Improved Performance

The first thing I noticed about **Word 4.0** is that the Alpha command is gone, and you can now toggle the command menu on and off with the Escape key. You can also remove the rectangular border from the screen if you are working in keyboard mode, which gives you two more lines for text. In the bottom left of the screen, there is now a column and line number counter showing the cursor position.

It is also easier to select commands from the command menu. In previous versions, you had to use the Tab key or press the first letter. In most situations, you can now use the cursor keys. I still find Word's command interface somewhat confusing. I'm never quite sure what the result will be when pressing the Enter key versus the cursor keys. This is, of course, a matter of habit.

In addition to the changes to the screen, Word 4.0 makes much better use of the function keys than previous versions. You can switch between graphics and text modes by pressing Alt-F9. Each function key is now assigned four command functions, three of which are accessed in combination with the Shift, Control, and Alt keys.

The most impressive change is the improvement in cursor speed, particularly in text mode. Word 4.0 has the performance attributes you normally get with an add-on keyboard enhancer like Cruise Control or Repeat Performance. The Options menu includes an option for adjusting the cursor speed. Using the highest cursor speed, it takes about 1 second to move the cursor from one end of the line to the other. The same operation takes about 5 seconds in Word 3.0 (using an IBM PC AT). Scrolling from top to bottom of a page takes about 10 seconds in Word 4.0 and about 15 seconds in Word 3.0. Search operations are very fast in both versions.

The new macro facility lets you build macros ranging from simple keystroke macros to complete menu systems with conditional branching. Microsoft also supplies a useful library of ready-to-use macros. In addition, Word 4.0 includes a redlining and revision-marking feature; a facility for automatically importing spreadsheets like Lotus 1-2-3, Microsoft Excel, and Multiplan; and a line-drawing option for creating boxes and borders.

Word 4.0 attempts to be the word processor for all users, from secretaries to lawyers to business executives to authors. It is loaded with options and features, and learning your way around the program is not a trivial exercise. For current users of Word, the $75 upgrade is well worth the price. For prospective new users, Word 4.0 has everything you could possibly want in a word processor, for a price of $450. The question to ask yourself is whether you need all those capabilities.

—Nick Baran

The Facts:
Word 4.0
$450 ($75 upgrade for current Word users)

Requirements:
IBM PC, XT, AT, PS/2, or compatible with 256K bytes of RAM, two floppy disk drives, and DOS 2.0 or higher.

Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073
(206) 882-8080
Inquiry 858.

continued

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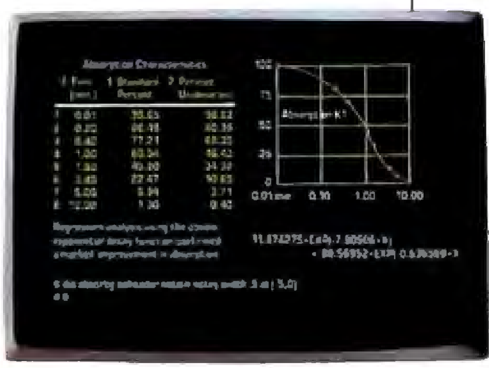

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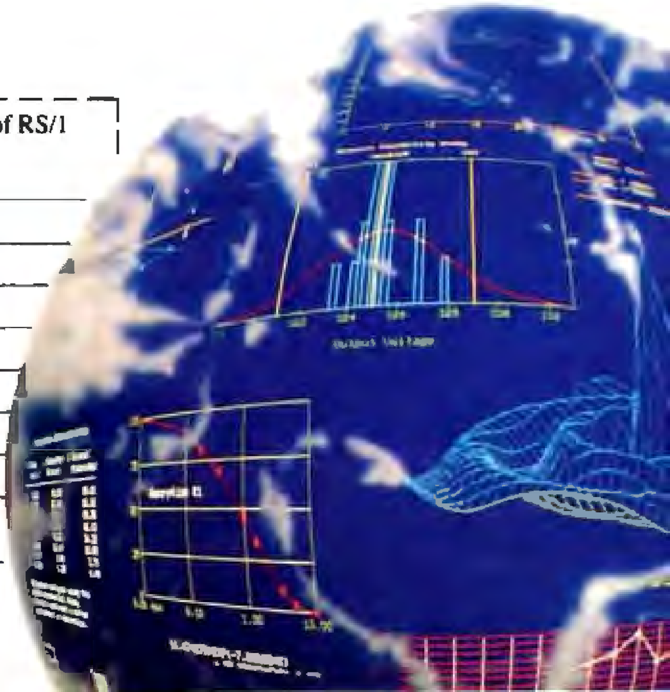

Circle 21 on Reader Service Card

A Solid Laptop

The Facts:

Portable Vectra
$2495

Options:
1200-bps internal modem, $450; Vectra DOS, $95.

Hewlett-Packard
Portable Computer Division
1000 Northeast Circle Blvd.
Corvallis, OR 97330
(800) 367-4772
Inquiry 856.

The **Portable Vectra** is a 16.6-pound laptop computer that features an 80C86 processor running at 7.16 MHz, 640K bytes of RAM, a 12-inch supertwist LCD screen, and a 25-pin parallel port. The model that I reviewed had two 3½-inch 720K-byte floppy disk drives and an internal 1200-bit-per-second modem.

The disk drives pop up from the case just above the full-size keyboard, much like those of the Zenith Z-183. Hewlett-Packard has provided room to store disks in the Portable Vectra in two fold-down holders next to the screen. These are a good idea, but if the holders are not tightly closed, floppy disks come spilling forth from the computer the next time it is opened.

The layout of the keyboard is one of the Vectra's strong points, with 92 keys and a separate numeric keypad next to the standard keyboard. The feel of the keyboard is strange due to the dimensions of the key tops. A normal IBM PC AT-type keyboard has key tops that are 12 mm (side-to-side) by 14 mm (front-to-back). The Portable Vectra reverses these two dimensions, and it bothered me.

The display on the Vectra is not backlit. Thus, it is not quite as readable as the Z-183 or NEC MultiSpeed EL displays. Without backlighting, the battery life is extended, with a rated life of 6 to 10 hours on a full charge. When the battery does need recharging, the external AC adapter/battery charger (6¼ by 2$^{15}/_{16}$ by 2⅛ inches) must be used, adding one more item to the package that has to be carried.

The Portable Vectra is not the fastest computer on the block. For example, in loading and recalculating a 100- by 25-cell Multiplan spreadsheet, the Portable Vectra was slower than the MultiSpeed, the Z-183, and even the IBM PC.

continued

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The TimeWand is simple to operate, yet provides the data necessary to create detailed reports. Generate reports by incorporating data collected with the TimeWand into your data base. The reports allow you to quickly find who has those important files, check a file's current activity, identify which items are 'slow movers', or show the amount of traffic the file room handles each day.

Circle 251 on Reader Service Card

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Single Recharger and Cable - $149
TimeWand Manager Software (Macintosh) - **$489**
TimeWand Communication Software (IBM) - **$299**

Videx

1105 N.E. Circle Blvd., Corvallis, OR 97330-4285
503-758-0521

Hewlett-Packard offers MS-DOS 3.2 and its Personal Applications Manager with the Portable Vectra.

All in all, the Portable Vectra is a solid-feeling, well-built portable computer with a few quirks (i.e., the size of the keys and the lack of backlighting). Hewlett-Packard has come out with a computer that will be usable and familiar if you're used to the keyboard and software of the HP 150. In competition with the Z-183, MultiSpeed EL, Toshiba T1100 Plus, and others, however, the Portable Vectra has little to make it stand out from the field.

—Curtis Franklin Jr.

A Big Chill for the PC and XT

The Facts:

Coldblue
$185

Requirements:
IBM PC or XT.

Mandrill Corp.
P.O. Box 33848
San Antonio, TX 78265
(512) 341-6155
Inquiry 857.

If you've added an accelerator card, an internal modem, or some expanded memory to your IBM PC, you may have noticed that it operates at a substantially higher temperature than it did back in the old days when it had only 256K bytes of RAM and monochrome and floppy disk controller cards. High temperatures (95 degrees F or more) can affect the service life and reliability of computer components. To cool things down, Mandrill has introduced an add-on cooling system called **Coldblue**, which snaps on to the front of the system unit behind the cover's front ventilation slots.

Coldblue consists of two small side-by-side cooling fans that force air across the expansion cards at a claimed rate of 25 cubic feet per minute. Using less than 2 watts of power, the unit works in an IBM PC with a 60-W power supply. Mandrill claims that Coldblue reduces operating temperatures by 20 percent or more.

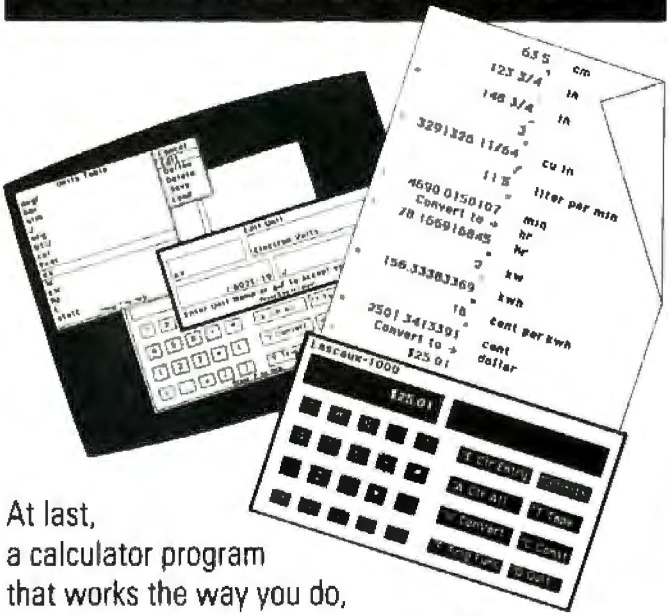
I tested Coldblue in an IBM PC with 640K bytes of standard memory, 1.5 megabytes of expanded memory, and a TurboEGA accelerator card, all generating plenty of heat. Installation was easy. After you remove the PC's cover, Coldblue's plastic fan housing snaps easily into place over the left front air inlet of the system unit.

To finish the installation, you attach two screw extenders to the back of the cover (five in an XT) and reinstall the cover with new screws supplied in the Coldblue package. When operating, Coldblue emits a blue luminescent light from the cover's ventilation slots.

The good news about Coldblue is that it definitely reduced the operating temperature in my PC. The PC's cover was noticeably cooler to the touch. Using a thermal measurement strip provided with Coldblue, I measured a temperature drop of about 10 degrees F in the left area of the PC's cover (where all those heat-producing cards are located).

The bad news is that Coldblue is very noisy. Contrary to Mandrill's claims, the fans are noisier than the power supply, producing a high-pitched whine. If you work in a large, bustling office environment, the noise may not be a problem. In a small, quiet room, however, the high-pitched whine of the fans is extremely irritating; so much so, in fact, that I had to remove Coldblue from my system.

continued



Coldblue is well worth the $185 investment if you can tolerate the noise.

—Nick Baran

Two Ways to Tackle Your 1987 Taxes

The Facts:

Ask Dan About Taxes
$69.95

Requirements:
IBM PC, XT, AT, or compatible with 512K bytes of RAM. A hard disk drive is recommended.

Legal Knowledge Systems Inc.
195 Maplewood St.
Watertown, MA 02172
(617) 923-2322
Inquiry 854.

Tax Preparer
IBM version, $295;
Apple version, $250

Requirements:
IBM PC, XT, AT, or compatible with 512K bytes of RAM. A hard disk drive is recommended.

HowardSoft
1224 Prospect St., Suite 150
La Jolla, CA 92037
(619) 454-0121
Inquiry 855.

Of the myriad programs designed to ease preparation of your 1987 taxes, I took a look at the prerelease versions of two: **Ask Dan About Taxes** and **Tax Preparer**.

Most tax programs require you to have either an extensive knowledge of the tax code or the patience to plow through the IRS booklets. Ask Dan is the first program I've seen that's designed to help the unstudied fill out their tax forms.

Ask Dan uses AI concepts in its queries. If you get confused while entering information, you call up the Ask Dan function with a single keystroke. Dan then asks you a question and, depending on your answer, either asks you additional questions or makes a recommendation. I found it particularly effective in figuring out filing status and exemptions for several oddball situations I made up.

Ask Dan is easy to install and speedy, and it includes the forms most taxpayers need. But Ask Dan help isn't available for every line of every form; you'll still need to have the IRS publications at hand. And if you need to file extremely complicated returns, Ask Dan—at least in the version I tested—isn't much help. It also needs at least rudimentary error checking. (I was able to enter an invalid social security number.) But if you file relatively simple returns, Ask Dan is

continued

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well worth its $69.95 price.

On the other end of the spectrum is Tax Preparer (TP) from HowardSoft. For the 1987 tax year, TP has gone through a major rewrite. Past versions suffered from molasses-like performance, but in the new version, the calculations and related functions are in machine language rather than BASIC, so it is much faster.

Installing TP is a real pain. Even if you're using a hard disk drive, you'll need MS-DOS and BASIC on floppy disks. Nevertheless, TP is a very powerful system. If you are filing only a simple return, it's definitely not for you. And because it has the capability to handle batch entry for multiple clients, it's especially suited to full-time tax preparers.

TP has features like split screen and automatic creation of forms from raw data. It also includes esoteric forms like the 2210 (penalty on estimated tax), the bane of tax preparers everywhere. For its features, TP's $295 price (for the IBM PC and compatibles) is reasonable. A partnership edition is also available for $495.

—Stan Miastkowski

Video Output Port Expander

The **Vopex-2M** video output port expander lets you connect two RGB or monochrome monitors to one video port. It works with the Apple Macintosh II computer and Macintosh II–compatible video cards.

Setup and operation are simple. Turn off the Mac II and its monitor. Disconnect the monitor from the video port. Connect the video port on the Mac to the input port of the Vopex-2M. (This cable is included with the unit.) Then plug the two external monitors into the output1 and output2 ports of the Vopex-2M. Flip on the power switch on the front panel of the Vopex-2M, and both monitors can display the same picture.

The Vopex-2M is a compact 2½- by 6- by 6⅓-inch box with its own built-in power supply. It contains active amplifiers for the red, blue, and green analog signals (lines 2, 3, 5, 9, and 12 on the DB-15 connector on the Mac II), with a 100-MHz bandwidth for no loss in resolution. This boost in the video signal permits positioning the monitors up to 100 feet from the computer, using a standard cable, or 250 feet using the optional low-loss video cables.

I tested the unit on a Mac II with 2 megabytes of RAM and 512K bytes of video RAM. I used a standard Mac II video card with 640- by 480-pixel resolution. I used the Conrac Model 7250 color monitor with a 19-inch screen and the Apple High-Resolution Monochrome Monitor.

The unit operated correctly on the Mac II. The displays on both monitors were crisp and sharp, with no loss in definition. Both monitors worked simultaneously with the Mac II in color or monochrome modes.

The Vopex-2M is ideal for situations where a group of people need to see the output from one computer.

—Stan Wszola

The Facts:

Vopex-2M
$279

Network Technologies Inc.
19145 Elizabeth St.
Aurora, OH 44202
(800) 742-8324.
Inquiry 852.

Options:
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Multiscan Color Monitors

George A. Stewart

Fourteen versatile displays that let you use today's wide range of graphics adapters

Personal computer graphics are on a technological joyride and have been ever since IBM introduced the open-architecture PC. Simply by plugging in the latest graphics adapter, you can now go from monochrome text to 320- by 200-pixel graphics with 4 of 16 colors (CGA), to 640 by 350 pixels with 16 of 64 colors (EGA), or to 320 by 200 pixels with 256 of 256,000 colors (VGA). New non-IBM-standard boards offer even higher resolutions. And because of Apple's use of open architecture, Macintosh II owners can look forward to the same kinds of upgrades.

The only problem is that replacing a graphics adapter often necessitates a more expensive replacement: the monitor itself. Multiscan color monitors—monitors that can operate over a wide range of horizontal and vertical synchronization frequencies—solve the upgrade problem by offering compatibility with every standard IBM graphics adapter around today. These monitors even offer a chance of compatibility with the higher-resolution graphics adapters that will be offered in the near future.

NEC pioneered the multiscan market with its MultiSync, introduced in late 1985, and Sony soon followed with its Multiscan CPD 1302. Today, you have a truly wide variety of monitors to choose from. BYTE looked at 14 multiscan monitors that range in price from under $700 to over $3100, all of them usable with CGA, EGA, and VGA display adapter cards, and sometimes usable with Hercules graphics cards and the Macintosh II graphics adapter. All the monitors accept digital and analog inputs (VGA and Macintosh II color use analog signals; the other adapters are digital). You can expect the choices to continue to grow; since we began this review, several companies, including NEC, have introduced new models.

In addition to performing usability tests and making subjective evaluations, we put 12 of the monitors through a series of objective tests using Microvision laboratory equipment custom-designed for measuring color monitor performance. (The equipment is described in the text box on page 112.) The two monitors we were unable to test with the Microvision equipment for various reasons (explained later) were the NEC MultiSync XL and Princeton Graphic Systems Ultrasync.

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Some Terminology

Color monitors reproduce colors as additive combinations of red, green, and blue phosphors uniformly arranged in triads across the inside surface of the display tube. (In the Sony monitor, the phosphors are arranged in alternating vertical stripes.) Corresponding to the three phosphors are three electron beams, each of which is supposed to illuminate only one phosphor color.

The *tridot pitch* is the distance between the RGB phosphor triads. All but three of the monitors tested have a tridot pitch of 0.31 millimeters; exceptions are the Nanao Flexscan (0.28 mm), the Princeton Graphic Systems Ultrasync (0.28 mm), and the Sony Multiscan (0.26 mm). A finer dot pitch implies the ability to represent finer detail in text and graphics.

Horizontal scan frequency is the rate at which the electron beam scans across the screen. Rates for the standard graphics controllers are 15.6 kHz (CGA), 21.8 kHz (EGA), 30.4 kHz (Professional Graphics Controller), 31.5 kHz (VGA), and 35 kHz (Macintosh II).

Vertical scan frequency is the rate at which each full frame of the display is drawn. At rates below 60 Hz, the display may flicker, producing eyestrain. Most of the monitors tested can handle rates from 45 Hz to 75 Hz or higher, enabling them to work with the graphics adapter standards listed above.

Bandwidth tells how fast the electron guns can turn on and off. The higher the bandwidth, the more individual points a monitor can have on each line and, thus, the higher the resolution. A bandwidth of about 34 MHz is needed for VGA displays, but some of the monitors we tested have bandwidths much higher—up to 65 MHz for the NEC MultiSync XL. The extra bandwidth gives a monitor greater upward compatibility with non-IBM-standard display controllers. For instance, the MultiSync XL offers 1024 by 768 resolution when used with NEC's MVA-1024 controller card.

Resolution—the maximum number of pixels on a horizontal and vertical line—

Conrac 7250
Electrohome ECM 1310, 1312, 1910
Logitech Autosync
Magnavox MultiMode
Mitsubishi Diamond Scan
Nanao Flexscan
NEC MultiSync Plus
NEC MultiSync XL
Princeton Graphic Ultrasync
Sony Multiscan
Taxan Multivision
Thompson Ultrascan

derives roughly from the bandwidth and the horizontal and vertical scan frequencies. Resolutions of the multiscan monitors we tested ranged from a low of 640 by 480 (for the Taxan Multivision 770 Plus) to a high of 1024 by 768 (for the NEC MultiSync XL).

To reduce the effects of ambient light, monitor manufacturers use several techniques. Two common methods involve etching the screen surface to diffuse and attenuate reflections and tinting the glass to improve contrast. Etched-surface monitors are easy to identify by the fact that reflections have soft edges. Etching the screen induces a certain amount of distortion of the pixels. Some monitors have a polished surface, reducing pixel distortion but giving sharp relections.

Digital signal input means the color monitor can reproduce only a finite number of colors corresponding to discrete signal levels from the graphics boards. For instance, the CGA's digital signals are R, G, B, and I (intensity), yielding 16 colors. The EGA gives R, r, G, g, B, and b, yielding 64 colors.

Analog signal input means the color monitor can reproduce infinitely many colors corresponding to continuously variable signal inputs for R, G, and B. In practice, the number of colors is limited by the graphics adapter. For instance, VGAs store 6 bits per color, yielding 2^{18} or over 256,000 possible colors. The Macintosh II stores 8 bits per color, yielding 2^{24} or over 16 million colors. A D/A converter located inside the adapter provides the driving analog signal for the monitor.

Compatibility and Subjective Testing

To test the monitors for compatibility with CGA, EGA, and VGA graphics, we used an IBM PC XT with the SigmaVGA card ($499) from Sigma Designs (46501 Landing Pkwy., Fremont, CA 94538). The card has separate outputs for digital and analog signals. Included with the card is a diagnostic program that puts test patterns on the screen and tests the monitor's response to various modes within CGA, EGA, and VGA specifications. According to its instruction manual, the SigmaVGA card is fully compatible with the IBM PS/2 BIOS.

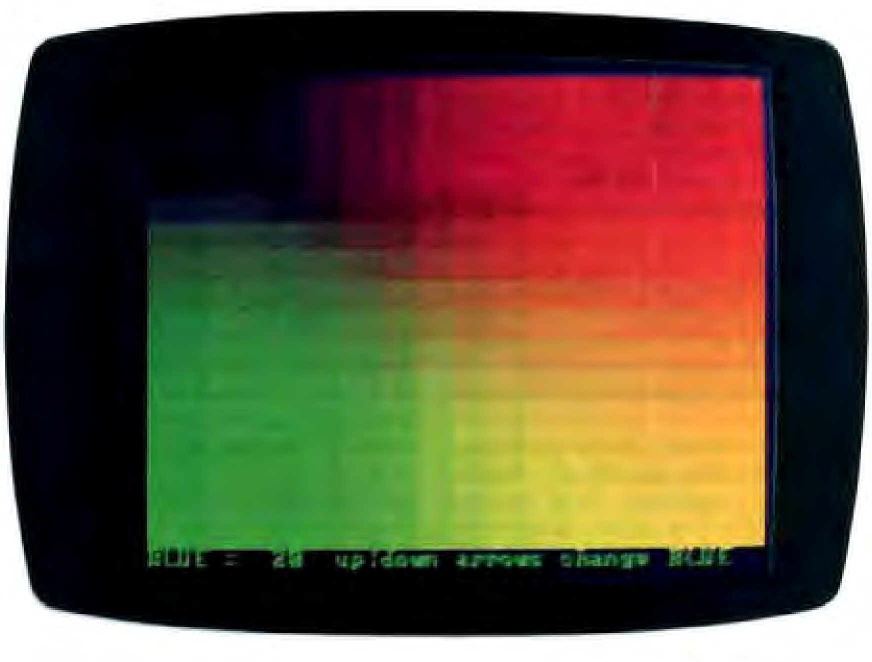
For reference purposes, we used an IBM PS/2 Model 80 connected to an IBM 8513 12-inch analog color monitor. The SigmaVGA diagnostic program ran just fine with the Model 80's built-in VGA circuitry, except when the program attempted to test SigmaVGA enhancements to the VGA standard. The SigmaVGA card does not work with the 8513 monitor, so we were unable to test the effects of the graphics card on this monitor.

The PS/2 system unit was placed about 2 feet to the right of the monitor being tested, and the PS/2 monitor was about 1 foot away from the tested monitor. As noted in the individual product reports that follow, many of the monitors were susceptible to electromagnetic interference (EMI) from the nearby PS/2 monitor, showing various degrees of instability. With every monitor tested, except the Electrohome ECM 1310, turning off the PS/2 monitor eliminated the problem. A few monitors (Conrac 7250, Electrohome ECM 1312 and ECM 1910, Magnavox MultiMode 8CM873, and NEC MultiSync XL) showed no interference from the nearby PS/2 monitor. If you plan to use two monitors or two separate systems close together, our tests show that you should consider the possibility of interference before selecting the monitors, and that you should choose one that is well-shielded against EMI.

In addition to the SigmaVGA diagnostic test, we ran a 256-color palette-shift program written in QuickBASIC 4.0 and provided by Microsoft. The test displays a 16 by 16 matrix of color boxes. Green shading ranged from maximum to 0 left to right; red ranged from maximum to 0

continued

Photo 1: *The 256-color palette-shift program (VGA mode), used for checking a monitor's ability to represent fine shades of color across the spectrum.*



top to bottom. The amount of blue is adjusted from maximum to 0 by keyboard control. The test let us check the monitor's ability to represent fine shades of color across the spectrum (see photo 1).

We also ran Microsoft's TORUS.BAS demonstration program, which puts a color image on a black screen and "rotates" it by shifting the color palette. This is a good test for gauging image/background contrast, and the color-on-black image produced is typical of standard CAD applications.

To test compatibility with the Macintosh II's color graphics board, BYTE technical editor Tom Thompson connected the monitors to a Macintosh II and displayed a variety of color image files and ran a color blit test. The color blit test randomly paints rectangular regions within a window on the screen. During these tests, most monitors were placed on top of the system unit; the exceptions were the 19-inch monitors, which were placed to the right of the system unit. Tom used Apple's 13-inch color monitor ($999) for the Mac as a reference for comparison. The Apple monitor surpassed all the reviewed monitors in both color quality and stability of the display.

During the Macintosh tests, we noted that a number of monitors showed EMI-induced fringing or instability around the edges of the picture area during disk accesses. The color blit test also produced instability around the edges on some displays; this would be a negative factor only for persons using the display in animation-intensive applications.

When using a tilt/swivel-base monitor with the Macintosh II, you must be careful not to place the base directly over the cooling vents on top of the system unit, because the base rests flat and would block the airflow. However, there is still room on the right side of the system unit for the monitor. We don't recommend placing the 19-inch monitors, which typically weigh about 55 to 75 pounds, on top of the system unit; they are simply too heavy for the plastic chassis to support.

Lab Tests

For low-level objective testing, we used equipment from Microvision, a company specializing in CRT measurement equipment. Each monitor went through a 30-minute warm-up period before we began testing it.

On each monitor, we set out to measure the following: spot size as a function of display brightness, time variance (swim, drift, and jitter), misconvergence, and voltage regulation. Fourteen tests were made on each monitor at two light levels, low and high. For most monitors, we used a low light level of 10 foot-lamberts; since the ECM 1910's high brightness level was only 11.1 ft-lamberts, we used 5 ft-lamberts as its low level. The high level varied, depending on the range of the monitor's brightness and contrast adjustments.

Figure 1 shows the levels used for low and high brightness for each monitor; in addition to documenting our tests, the information gives a rough idea of the brightness range of the monitor. The Electrohome ECM 1310 had the widest range (10 to 30 ft-lamberts), and the Electrohome ECM 1910 had the lowest (5 to 11.1 ft-lamberts).

Spot size is the minimum size that can be illuminated by the beam. Microvision equipment gives separate readings for horizontal and vertical dimensions. To come up with a single number, we took the square root of the sum of the squares of the horizontal and vertical measurements; this would correspond to the length of the diagonal line across a spot. It is important to take overall screen size into account when comparing spot sizes; a 0.8-mm spot size on a 19-inch screen will appear finer than the same spot size on a 13-inch monitor.

Spot size is interesting as an absolute measurement: It shows the true fineness of the display beyond the nominal dot-pitch specification. The monitors we tested showed a minimum spot size ranging from 0.4 mm (NEC MultiSync Plus and Electrohome ECM 1910) to 0.8 mm (Mitsubishi Diamond Scan AUM 1371A). It is also interesting to note how the spot size changes from the center of the screen (best case) to the upper left corner (usually the worst case). In a perfectly designed monitor, there would be no change. The MultiSync Plus was 0.6 mm in the corner; contrary to the general rule, the Mitsubishi Diamond Scan's spot size went down to 0.6 mm. The Nanao Flexscan showed the least change in spot size from center to corner.

We also measured how spot size changed with respect to brightness. As brightness is increased, the spots tend to enlarge, or "bloom." The less they bloom, the better: It means the resolution is independent of its brightness. The Electrohome ECM 1310 had the greatest degree of blooming in the center and corner of the screen. The Electrohome ECM 1312, Logitech Autosync, Mitsubishi Diamond Scan, and Taxan Multivision all had small bloom factors in the center, and the ECM 1312, Conrac 7250, and NEC MultiSync Plus were all low-bloomers in the corner.

The spot size results are presented in figures 2 and 3. Note that the spot sizes have been adjusted for screen size, using 13 inches as the standard size: adjusted spot size = actual spot size × (13/screen size).

Time variance measures undesirable fluctuations in the beam position in terms of millimeters per time interval. High-frequency movement (at 0.5-second intervals) is called *jitter*. Medium-frequency movement (10-second intervals) is called *swim*. Low-frequency movement (60-second intervals) is called *drift*. Microvision equipment measures horizontal and vertical time variance separately and records the average and maximum variances for jitter, swim, and drift. Large amounts of drift can make it difficult to do precision graphics or CAD work; higher-frequency jitter and swim can cause eyestrain.

NEC, Nanao, and Taxan monitors performed best on the jitter, swim, and drift tests. The Magnavox MultiMode had by far the worst jitter, swim, and drift. Figures 3a, 3b, and 3c present the average time-variance results, with only the exceptional cases (best and worst) called out; linear measurements have been adjusted to account for screen size.

Misconvergence measures the amount of error in electron beam/phosphor dot alignment. Severe misalignment causes white text to seem to have fringes of color. We measured misconvergence at the center of the screen (best case) and at the upper left corner (worst case). Microvision equipment measures separately the error in RG, BG, and RB convergence in horizontal and vertical directions. The Electrohome ECM 1312 had the lowest overall misconvergence, although a number of other monitors did well on one or more of the tests. Logitech's Autosync rated poorly on three of the four misconvergence tests.

Figures 4a, 4b, 4c, and 4d present the misconvergence test results. Note that the linear measurements are adjusted for screen size.

Ideally, the position of a line or shape of an image on the screen should be independent of the rest of the screen's contents. For instance, a line across the top of an otherwise black screen shouldn't move when the rest of the screen is filled with white. The actual amount of change is determined by the monitor's internal *voltage regulation* (not related to line voltages within the normal range).

To test the monitors, we compared the position of a horizontal line at the top of the screen when the rest of the screen was black and then when the screen was white. We did the same thing for a vertical line along the left side of the screen. The Microvision equipment measured the difference in top and side positions in millimeters. As with spot size, we pro-

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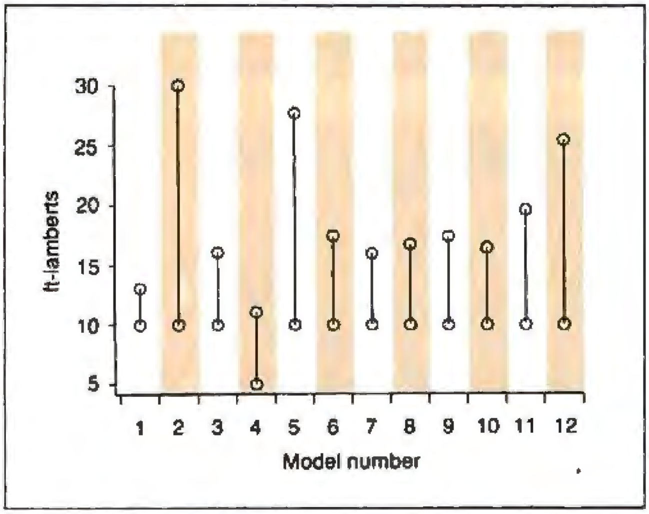

Figure 1: *Brightness levels, with high and low settings emphasized. Wide range is preferable.*

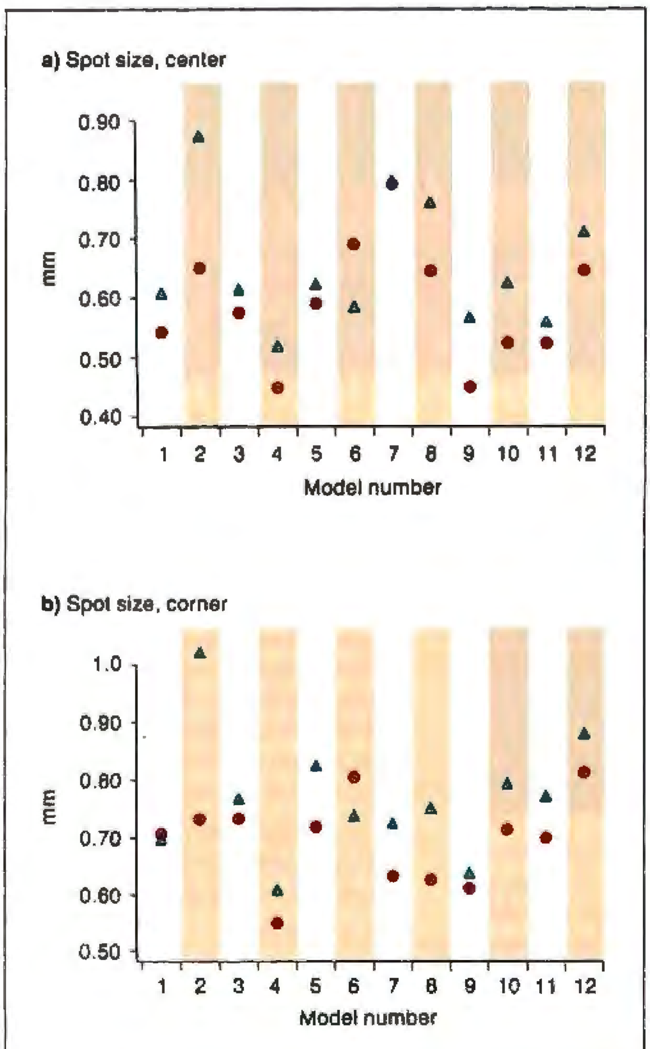

Figure 2: *Spot size at high (▲) and low (●) brightness, adjusted to account for screen size. Small spot size and small difference between high and low levels are desirable.*

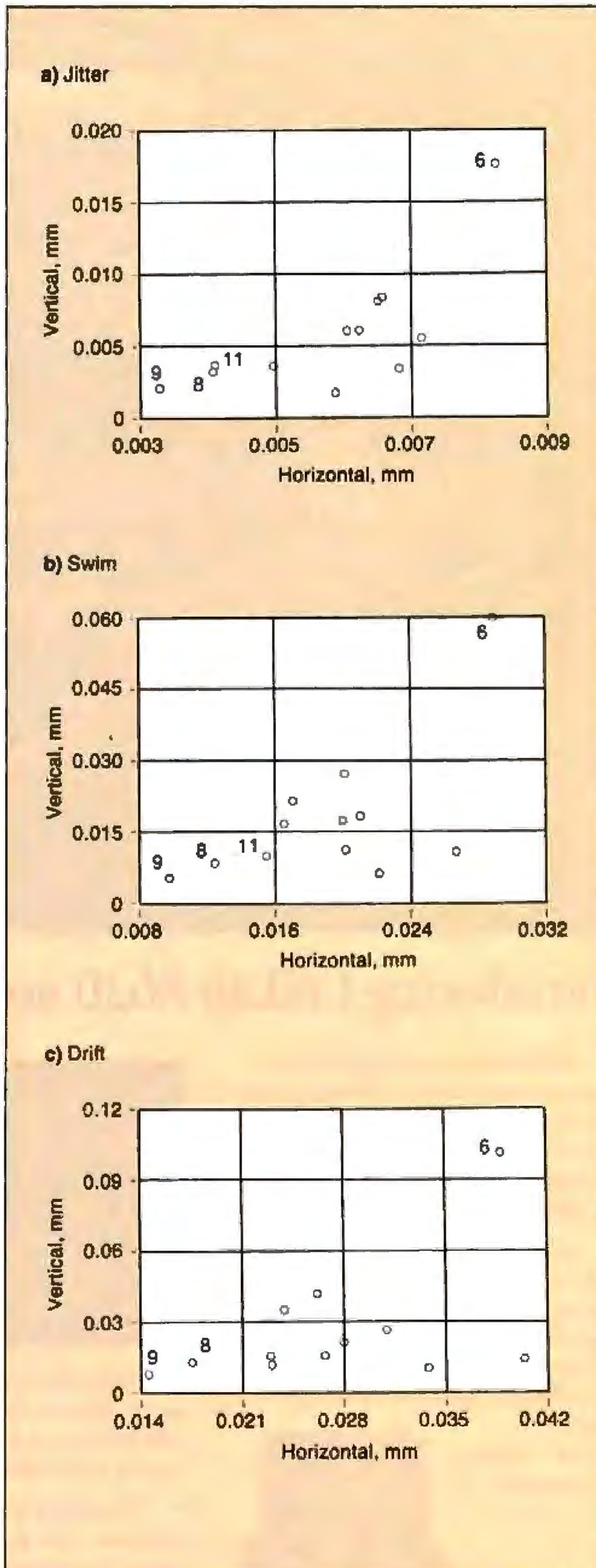

Figure 3: *Vertical vs. horizontal time variance. Only extreme low and high cases are identified. Measurements are adjusted to account for screen size. Small variance is preferable.*

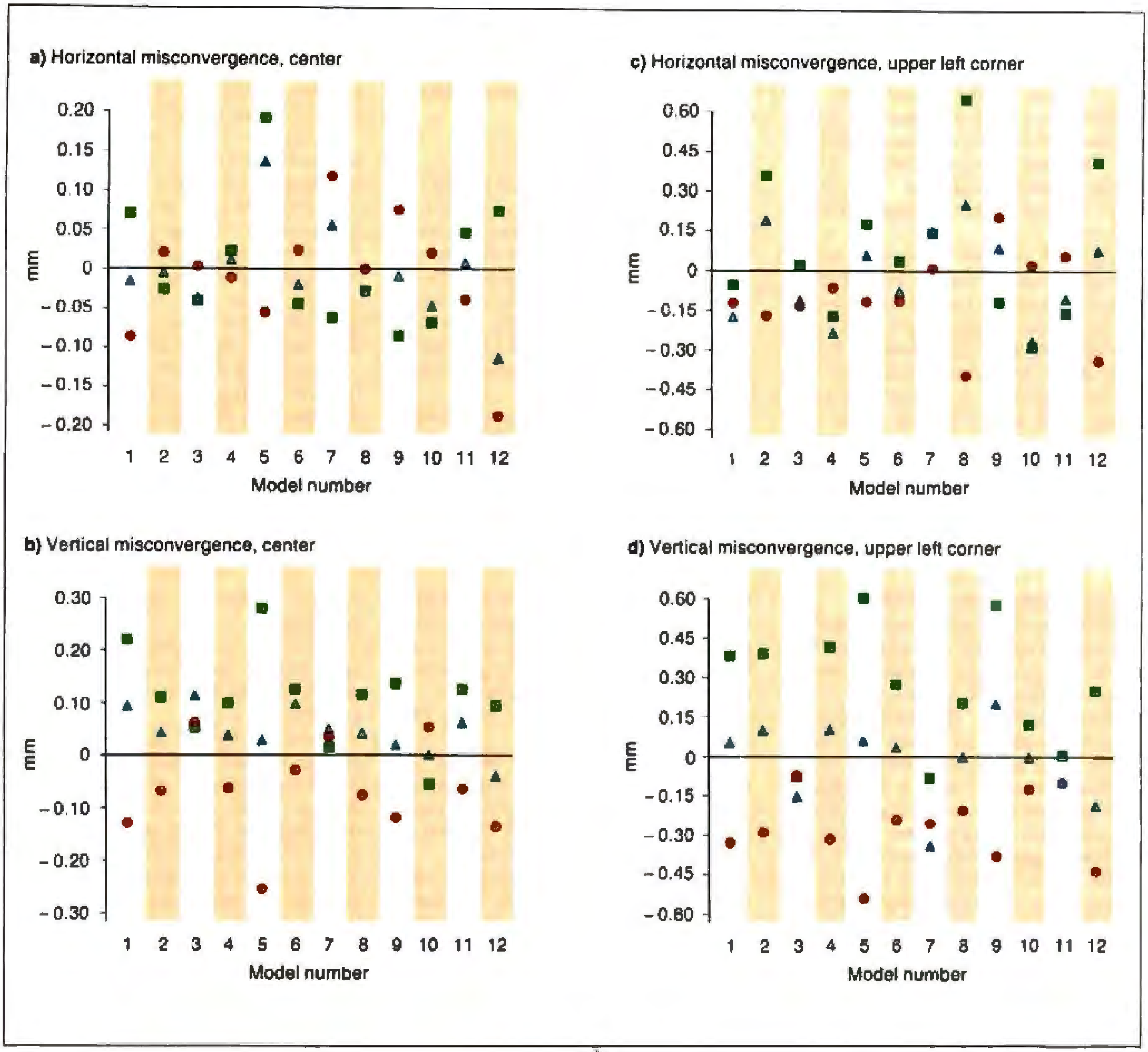

Figure 4: *Misconvergence in mm. Linear measurements have been adjusted to account for each monitor's screen size. Low error (close to zero line) is preferable.* ▲ *= red-to-green error,* ● *= blue-to-green error,* ■ *= red-to-blue error.*

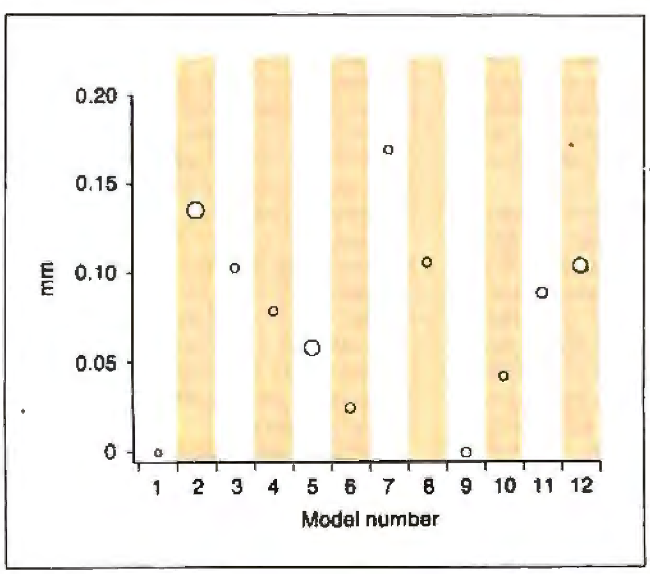

Figure 5: *Voltage regulation: line displacement in mm adjusted for screen size. The height of each circle is proportional to the amount of line displacement, and the size of each circle is proportional to the brightness range. Low displacement and large brightness range are preferable.*

Key to Model Numbers

1	Conrac 7250	7	Mitsubishi AUM 1371A
2	Electrohome ECM 1310	8	Nanao 8060S
3	Electrohome ECM 1312	9	NEC MultiSync Plus
4	Electrohome ECM 1910	10	Sony CPD 1302
5	Logitech TE5155	11	Taxan 770 Plus
6	Magnavox 8CM873	12	Thompson 4375M

duced a single number as the vector sum of the horizontal and vertical movement. To factor in screen size, we then divided this number by the screen size. The smaller the amount of change, the better.

The NEC MultiSync Plus and the Conrac 7250 had 0 percent change—that is, perfect voltage regulation. The Mitsubishi had the highest change, about 17 percent.

Figure 5 presents the results for the voltage regulation test. In evaluating the results, it is well to keep in mind the overall brightness range of each monitor; a monitor with a low upper limit for brightness should have a much easier time with voltage regulation. A monitor with a high upper limit for brightness might look much better if used at a lower brightness. The size of each circle in the figure is proportional to that monitor's brightness rating. For instance, the Nanao and Thompson monitors both have a moderate line movement of 0.1 mm. However, the Thompson has a considerably wider brightness range, judging from the size of the circles in the figure.

Clear Winners

All 12 of the monitors tested passed our CGA, EGA, and VGA compatibility tests; 11 passed the Macintosh compatibility tests (we could not test the Logitech Autosync with the Mac II because the appropriate cable was not supplied). However, as you'll see from the individual product reports, a number of performance variables made it easy to select favorites.

For color purity and overall stability, we liked the Electrohome ECM 1312; however, that monitor uses long-persistence phosphors and would not be suitable for many animation applications.

For the Macintosh II, none of the monitors beat out Apple's own color monitor. The Sony placed a close second in color quality and stability, and the ECM 1312 matched it in color quality.

Of the two 19-inch monitors that we lab-tested, the ECM 1910 had the lowest misconvergence in the center; the two rated about the same in the corner. Conrac had perfect voltage regulation; ECM 1910's was about average. The ECM 1910 had slightly finer spot size. Time variance on the two units was about the same. In subjective testing, Conrac had better stability during color blits.

Considering the rest of the monitors: For overall fineness of display, Sony and NEC were the winners. NEC had the best time-variance rating. Among bargain monitors, the Taxan Multivision ($795) turned up in the top two or three more frequently than any other under-$900 monitor.

Closer Looks: Conrac 7250

This is one of the three largest monitors we tested. The $2995 unit measures 19 by 14 by 22 inches and weighs 68 pounds. The 19-inch screen surface is etched to diffuse reflections. The bezel is deep, reducing the effects of lateral reflections. Front panel adjustments include brightness and contrast. There is a switch for text/graphics mode and a degauss button for use when colors become impure due to magnetization of the picture tube. Due to the 22-inch depth of the monitor, the placement of the power switch on the rear is a little inconvenient. The brightness control adjusts the normal-intensity colors and has little or no effect on the high-intensity colors. Contrast affects all colors uniformly. Response to both controls was somewhat rough and nonlinear.

Rear panel controls are few: power, analog/digital, and a couple of switches for use with non-IBM-compatible computers in digital mode. The unit has no external adjustments for vertical or horizontal position and size. A single D-shell plug handles analog and digital inputs.

According to specifications, the unit has a bandwidth of 40 MHz and a maximum resolution of 1024 by 600. Horizontal scan range is up to 37 kHz, and vertical scanning is from 48 to 60 Hz automatic, internally adjustable to 80 Hz.

The unit had no difficulty locking onto the various horizontal frequencies used in the SigmaVGA diagnostic test. In the 16-color comparison test, the Conrac had darker browns, deeper reds, and brighter greens than the PS/2 monitor. In the 256-color palette test, a slight color-purity problem was noticeable in the lower right corner of the screen; all colors showed a blue tint. The degauss button didn't help. However, the black-background torus test was extremely sharp; due to the black background, the color-purity problem in the lower right was not evident.

No interference from the nearby PS/2 monitor was noted.

When connected to the Mac II, the Conrac monitor was very stable during color blits and disk accesses. Colors were also excellent, though not as good as those on the Apple color monitor.

The 28-page *User's Guide* gives clear explanations of installation, operation, and troubleshooting. The warranty is one year parts and labor.

Electrohome ECM 1310

The $1198 ECM 1310 measures 13 by 14 by 16 inches and weighs 29 pounds. The 13-inch screen surface is etched, and reflections are diffused. The bezel is deep enough to reduce reflections. Front panel controls include brightness and contrast adjustments and a power switch. Brightness adjusts all but high-intensity colors; contrast adjusts all colors. Response to both controls was smooth.

The rear panel is loaded with controls: analog/digital, underscan on/off (for use with low horizontal-frequency display adapters, such as CGA), and separate sets of vertical/horizontal size and position adjustments for analog and digital inputs. The digital input plug is a 9-pin D-shell plug. For analog input, the unit has separate BNC-type plugs for horizontal sync, vertical sync, blue, green, and red. A corresponding set of BNC output plugs lets you connect one or more additional monitors to be driven from the same input signal. The placement of the size and position controls on the rear is a little inconvenient.

Bandwidth is 30 MHz. Resolution is up to 720 by 540. Horizontal scan frequency is up to 34 kHz; vertical scan, 47 to 85 Hz.

In the SigmaVGA diagnostic test sequence, the unit made especially smooth transitions between the various screen modes. There was some blooming of text, except at low brightness levels. In the 16-color test, the brown color had a slight orange tint, and a color-purity problem was noticeable on the left side (colors were orange instead of red).

In the full-screen 256-color palette test, some fuzziness was visible at the edges of the image. The unit flickered significantly; turning the nearby PS/2 monitor off did not reduce the flicker. Flicker was especially noticeable when blue was set to maximum value in the 256-color palette test. In the torus test, adjusting the contrast control affected the tint of the colors. Electrohome offers a metal-case version of the monitor ($1587) that, according to the company, eliminates monitor cross talk and other interference problems.

When the monitor was connected to the Macintosh II, there was a faint shade of magenta or blue on the entire screen, but this effect soon became unnoticeable due to the eye's adjustments. Because the monitor uses short-persistence phosphors, no color streaking was present during animations.

Documentation consists of a four-page brochure with four operation steps, a few cautions, a control/connection diagram, and specifications. No troubleshooting

continued

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Name and company	Price	Screen size	Accessories
Model 7250 Conrac Corp. 1724 South Mountain Ave. Duarte, CA 91010 (818) 303-0095 **Inquiry 906.**	$2995 with short-persistence phosphor; $3095 with long-persistence phosphor	19-inch	**Included:** 9- to 9-pin cable **Optional:** Tilt-swivel stand, $100; PS/2 adapter, price pending
Electrohome ECM 1310 Electrohome Ltd., Display Systems 809 Wellington St. N Kitchener, Ontario N2G 4J6 Canada (519) 744-7111 **Inquiry 907.**	$1198; metal-case version, $1587	13-inch (etched, short-persistence)	**Optional:** Tilt-swivel stand, $54, cables, price pending
Electrohome ECM 1312 Electrohome Ltd., Display Systems **Inquiry 908.**	$1198; metal-case version, $1587	13-inch (polished, long-persistence)	**Optional:** Tilt-swivel stand, $54, cables, price pending
Electrohome ECM 1910 Electrohome Ltd., Display Systems **Inquiry 909.**	$2795 (metal-case version not available)	19-inch (etched, long-persistence)	**Optional:** Tilt-swivel stand, $106, cables, price pending
Autosync TE5155 Logitech Inc. 6505 Kaiser Dr. Fremont, CA 94555 (415) 795-8500 **Inquiry 910.**	$699	13-inch	**Included:** Tilt-swivel stand, 9- to 9-pin cable
MultiMode 8CM873 Magnavox N.A.P. Consumer Electronics Corp. P.O. Box 14810 Knoxville, TN 37914 (615) 521-4316 **Inquiry 911.**	$899	13-inch	**Included:** 9- to 9-pin cable **Optional:** Tilt-swivel stand, $29.95; PS/2 cable, $24.95, Mac II cable, $39.95
Diamond Scan AUM 1371A Mitsubishi Electronics America Inc. 991 Knox St. Torrance, CA 90502 (213) 515-3993 **Inquiry 912.**	$889	13-inch	**Included:** 9- to 9-pin cable **Optional:** Tilt-swivel stand, $30, PS/2 cable, $19.50

information or detailed operation instructions are provided. Warranty is one year parts and labor.

Electrohome ECM 1312

The $1198 ECM 1312 has a long-persistence phosphor and a clear, polished screen surface. Reflections off the 13-inch screen are sharp but unobtrusive. Otherwise, the unit is identical in size, weight, controls, and inputs to the ECM 1310 (see photo 2).

The long-persistence phosphor has a curious effect on blinking images, such as a blinking cursor or blinking text: The green phosphor seems to have a slower decay rate than the red or blue, so white images leave a trace of green before they disappear during the blinking cycle.

In the 16-color test, the ECM 1312's colors closely matched those of the PS/2 display. In the 256-color palette test, this unit had the best apparent color definition of all the units tested. For instance, in the green/red palette with blue set to zero, this unit showed the clearest yellow in the lower right corner; other units didn't have such a clear progression.

As is to be expected with a long-persistence display, no flicker was noted when the nearby PS/2 monitor was on.

Connected to the Macintosh II, this monitor had the best colors of all the units we tested—as good as the Apple color monitor. However, there was noticeable color streaking during screen animations, such as opening and closing windows and moving the pointer around the screen; this is an unavoidable side effect of having long-persistence phosphor. The benefit of this kind of phosphor is that the monitor is very steady during color blits and hard disk accesses.

Documentation consists of a four-page brochure with minimal information about controls, connections, and pin assignments. Warranty is one year parts and labor.

Electrohome ECM 1910

This $2795 monitor has a 19-inch screen with a short-persistence phosphor. Its outer surface is etched, and reflections are diffused. Its dimensions are 17 by 19

Name and company	Price	Screen size	Accessories
Flexscan 8060S Nanao USA Corp. 23510 Telo Ave., Suite 5 Torrance, CA 90505 (213) 325-5202 **Inquiry 913.**	$919	13-inch	**Included:** Tilt-swivel stand; 9- to 9-pin cable **Optional:** PS/2, ATT 6300, and Mac II cables, $49 each
MultiSync Plus NEC Home Electronics (USA) Inc. 1255 Michael Dr. Wood Dale, IL 60191 (312) 860-9500 **Inquiry 914.**	$1395	14-inch	**Included:** Tilt-swivel base, 9- to 9-pin cable, PS/2 cable **Optional:** 9-pin to 4-plug BNC cable, $35; Mac II cable, $19.95
MultiSync XL NEC Home Electronics (USA) Inc. **Inquiry 915.**	$3195	19-inch	**Included:** Tilt-swivel base, 9- to 9-pin cable, PS/2 cable **Optional:** 9-pin to 4-plug BNC cable, $35; Mac II cable, $19.95
Ultrasync Princeton Graphic Systems 601 Ewing St., Bldg. A Princeton, NJ 08540 (609) 683-1660 **Inquiry 916.**	$795	12-inch	**Included:** Tilt/swivel stand, 9- to 25-pin cable, 15- to 25-pin cable **Optional:** Mac II cable, $19.95
Multiscan CPD 1302 Sony Corp. Sony Dr. Park Ridge, NJ 07656 (201) 930-1000 **Inquiry 917.**	$945; with stand and cable, $975	13-inch	**Optional:** Tilt-swivel stand, 9- to 9-pin, 15- to 9-pin, and Mac II cables
Multivision 770 Plus Taxan USA Corp. 18005 Cortney Court City of Industry, CA 91748 (818) 810-1291 **Inquiry 918.**	$795	14-inch	**Optional:** Tilt-swivel stand, $40; PS/2 and Mac II cables, $25 each
Ultrascan 4375M Thompson Consumer Products Corp. 5731 West Slauson Ave., Suite 111 Culver City, CA 90230 (800) 325-0464 In California, (800) 237-9483 **Inquiry 919.**	$895	13-inch	**Included:** Tilt/swivel stand, 9- to 9-pin cable **Optional:** PS/2 cable and Mac II cable, $30 each

by 21 inches, and it weighs 74 pounds. Front panel controls are brightness, contrast, and power; all function as on the ECM 1310. Rear panel controls are like those on the ECM 1310, with the addition of a degauss button.

Bandwidth is 30 MHz. Resolution is up to 1024 by 512. Horizontal scan frequency is up to 34 kHz; vertical scan, 47 to 85 Hz.

The unit locked onto the various frequencies used in the SigmaVGA diagnostic test. In the 16-color display, the blues were deeper than those on the PS/2 screen. The white had a faint pink tint. Brown appeared to have less red than the PS/2 monitor's brown. There was no flicker. This monitor had less light output than some of the others and might not be a good choice for use in bright office conditions.

In testing with the Mac II, the monitor showed good, bright colors with brightness cranked up to the maximum. The entire screen shakes a bit during color blits.

Documentation consists of seven pages briefly explaining connection, controls, pin assignments, and specifications. No troubleshooting information or detailed operation instructions are provided. Warranty is one year parts and labor.

Logitech Autosync TE5155

This $699 monitor has overall dimensions of 13 by 15 by 15 inches and weighs 31 pounds. Its 13-inch screen is polished. The bezel is deep, and overhead lights throw a shadow on the top edge of the screen.

All the commonly used controls are conveniently located on the side panel behind a flip-open cover. These controls include switches for text mode on/off and horizontal width on/off; and adjustments for contrast, brightness, horizontal and vertical position, and horizontal and vertical size. The size and position of controls close to the front make it easier to adjust the picture.

On the rear panel you'll find additional controls to select the scan mode and analog/digital input. A set of microswitches selects the color to be used in

continued

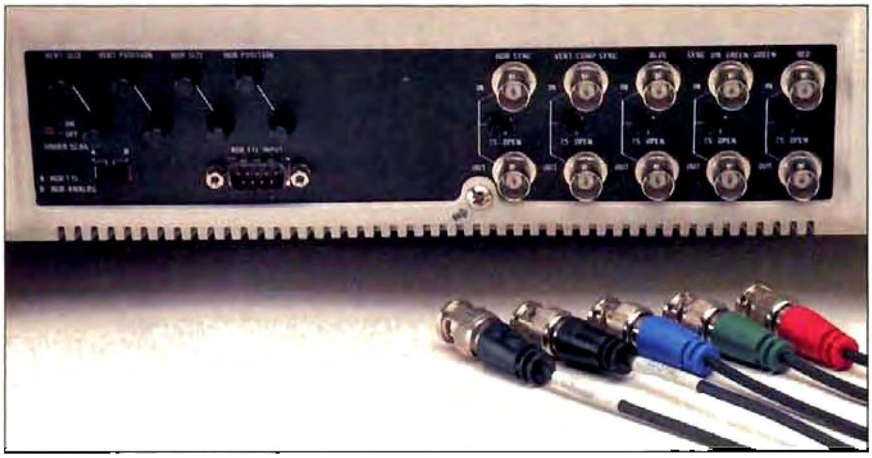

Photo 2: *The rear panel of the Electrohome ECM 1312 includes most of the connector types and adjustments mentioned in the product descriptions.*

text mode; any of eight colors may be selected. Additional microswitches let you adapt the monitor for use with various non-IBM color adapters. A single 9-pin D-shell plug accepts analog and digital inputs.

Video bandwidth is 40 MHz. The maximum resolution is 800 by 560. The horizontal scanning rate is up to 35 kHz; vertical, 45 to 80 Hz.

The picture shifted positions in certain modes in the SigmaVGA diagnostic test, requiring additional setting of the horizontal position and size controls. Colors were very close to those on the PS/2 display, with reds a little deeper and whites not quite so white. In the 256-color palette screen, some flicker was noticeable with the PS/2 screen turned on; the flicker stopped when the PS/2 display was turned off. We did not test this monitor with the Macintosh due to the absence of a connector cable.

The documentation we received with the unit was preliminary. Warranty is one year parts and labor.

Magnavox MultiMode 8CM873

This $899 unit measures 13 by 14 by 15 inches and weighs 29 pounds. The 13-inch screen is etched, and reflections are diffused.

On the front panel are the controls for text/normal mode, brightness (which adjusts all but the high-intensity colors), contrast (which adjusts all colors), horizontal position, volume (of the audio input), and power. The rear panel has controls for normal/special inputs and analog/digital. Recessed screw adjustments are also provided for setting vertical hold, vertical position, and vertical size (three separate controls for three frequency ranges). Adjusting these controls requires a screwdriver. A single 9-pin D-shell plug accepts digital or analog inputs, and an RCA-type plug accepts audio signals.

Bandwidth is at least 25 MHz, according to specifications, and maximum resolution is 926 by 580. Horizontal scanning frequency is up to 34 kHz; vertical scanning frequency is 52 to 78 Hz.

During testing, it was necessary to adjust the horizontal position several times to keep the image centered on the screen, depending on what mode was selected. For instance, the 256-color palette test required a different horizontal position setting from the default text mode.

Colors were similar to those on the PS/2 monitor. Connected to the Macintosh II, colors were not so bright as those of other monitors, and a slight fringing effect was noted during hard disk operations. Selecting the text mode on the monitor causes the entire image to be displayed in green (in analog operation, only the green signal is displayed). No interference from the PS/2 monitor was noted.

The 12-page installation and operation guide includes explanations of the controls and inputs, maintenance tips, and troubleshooting help. The MultiMode comes with a 12-month limited warranty.

Mitsubishi Diamond Scan AUM 1371A

This $889 unit measures 13 by 14 by 15 inches and weighs 28 pounds. Its 13-inch screen is coated to diffuse reflections and has a medium-depth bezel.

Recessed under the front panel are controls for brightness (affects all but high-intensity colors), contrast (affects all colors), and power. Rear panel controls include digital/analog/composite video, color and tint adjustments (when using the composite video input), horizontal and vertical position, horizontal and vertical size, overscan/underscan, and monochrome/normal (the monochrome setting is for use with a monochrome display adapter). The unit has separate inputs for RGB analog, RGB digital, and composite color video, as from a VCR, and has facilities for superimposing one image over another. There are three input plugs: a 9-pin D-shell plug for digital RGB, a 25-pin D-shell plug for analog RGB, and a BNC plug for composite color video.

Bandwidth is 30 MHz; maximum resolution is 800 by 560. Horizontal scan rate is up to 35 kHz; vertical scan, 45 to 75 Hz.

Reflections on the screen were almost sharp, and the screen had a noticeable high-frequency flicker while the nearby PS/2 monitor was powered on. Compared with the PS/2 monitor, reds were brighter, blues were deeper, and the white had a paper-white quality.

When the unit was connected to the Mac II, we noticed fringing during hard disk access. Colors were a little muted, not as good as the Conrac or Sony monitors. The screen image area changed size as the image contents changed.

The 14-page manual includes detailed explanations of controls, timing diagrams, and special applications such as superimposition of images and remote control of the input selecting signal. Warranty is one year on parts and labor.

Nanao Flexscan 8060S

This $919 monitor has a dot pitch of 0.28 mm, very small compared to the 0.31 pitch of most of the other monitors we tested. The unit has a 13-inch etched screen, measures 13 by 14 by 16 inches, and weighs 29 pounds. The bezel is fairly deep, limiting the effects of nearby light sources.

Most of the adjustments are conveniently located on the front panel: brightness (adjusts all colors), contrast (adjusts all but high-intensity colors), horizontal size, vertical size, amber/color/white (the amber and white positions are for use with monochrome adapters), and power. The power-on LED glows orange when the unit is set for digital operation and green when the unit is set for analog operation.

Rear panel controls include vertical position, horizontal position, color mode (automatic preset or manually set to 8/16/64 colors), and analog/digital. The signal input is a single 9-pin D-shell plug.

The Nanao's bandwidth is greater than 30 MHz, according to specifications, and its maximum resolution is 820 by 620. Horizontal scanning rate is up to 35 kHz; vertical, 50 to 80 Hz.

In the 16-color test, the colors of the 8060S were very close to those of the

continued

The Test Equipment

All objective testing was done with the Superspot 100 CRT analysis system from Microvision Inc. (591 West Hamilton Ave., Suite 250, Campbell, CA 95008). The system included an IBM PC-compatible computer with custom software, an optic module and controller board, and the Spotseeker II positioning system for computer-controlled movement of the optic module. To drive the monitors, we used the ATI EGA Wonder display adapter.

To measure line width, the optic module is imaged on a horizontal (or vertical) line and focused. The real-time display shows an intensity profile on the test computer's monitor. The Superspot software uses either a Gaussian or surface fit to overcome the gaps in intensity caused by the CRT shadow mask.

For convergence error measurements, the control program displays a red, green, and blue line. It then calculates the centroid of each line and the error in red to green, green to blue, and blue to red.

For time variance, the computer checks the line position at varying intervals over a test period, displaying the results as a histogram (see figure A). For the voltage regulation test, we used the optic module to find the location of a line when the rest of the screen was black versus when it was white, recording the movement of the line as a measure of voltage regulation.

Microvision engineers Dave Buckstad and Kraig Chellew brought the equipment to BYTE offices in Peterborough and conducted the tests.

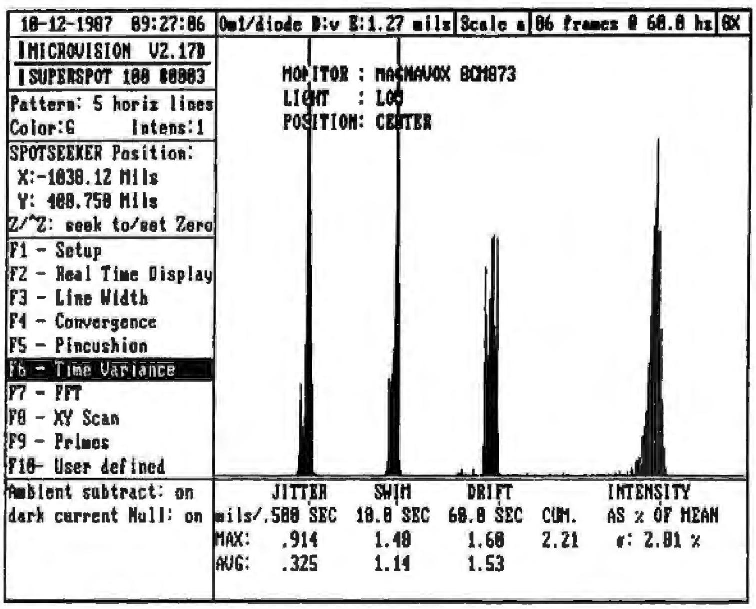

Figure A: *Sample time-variance data sheet generated by the Microvision equipment.*

PS/2 monitor. Some flicker was noticeable; it went away when the nearby PS/2 monitor was turned off. In the 256-color palette test, it was not possible to see the different shades in the upper left corner; contrast was limited there. In the SigmaVGA diagnostic test, the image area changed sizes as the test program shifted display modes. In particular, test 6A, the SigmaVGA 320 by 350 text mode, was very faint on this monitor.

When tested with the Macintosh II, the unit had a definite screen-image shudder during disk access—the worst of all the monitors tested. Some blurring or focus problems appeared when contrast wasn't set properly. Colors on the screen were muted compared to the Apple monitor.

The 13-page manual provides brief operating instructions, pin assignments, timing diagrams, and specifications. Warranty is one year parts and labor.

NEC MultiSync Plus

This $1395 unit measures 15 by 14 by 16 inches and weighs 40 pounds. The 14-inch screen shows sharp reflections, but they are attenuated so as not to be distracting. The bezel is of medium depth, and no shadow is cast on the screen from overhead lights.

Most of the controls are conveniently located behind a flip-down door on the front panel. Brightness affects all colors, and contrast affects all but the high-intensity colors. Other front panel controls are horizontal/vertical size and position, monochrome text mode/color mode, text color, and an input selector specifying BNC or D-sub. For text display, the text mode switch lets you select green, amber, or white. The NEC MultiSync Plus is the only one of the units tested that includes its own cooling fan. The unit also includes a tilt-swivel stand.

Back panel controls are switches for analog/digital, BNC input voltage, IBM or non-IBM input mode, and 8/16/64 colors in non-IBM mode. A single 9-pin D-shell plug accepts digital and analog RGB inputs, and four BNC plugs accept analog RGB input from high-resolution graphics adapter boards.

Specifications give a bandwidth of 55 MHz when BNC connectors are used and 30 MHz with the D-shell connector. Maximum resolution is 960 by 720. Horizontal scanning rate is up to 45 kHz; vertical, 56 to 80 Hz.

In the 16-color mode of the SigmaVGA diagnostic test, colors on the NEC monitor were very close to those on the PS/2 monitor. Switching between modes was smooth; it was not necessary to adjust horizontal position when the test program changed the frequency. The appearance of the 256-color palette test and torus were also similar to those on the PS/2 display.

In the Macintosh II tests, the unit showed slight fringing during disk accesses. Colors appeared muted compared to the Apple monitor, and there was some flutter during the color blit test.

If you place this unit on top of the Mac II, you must place it on the right side, clear of the air vent. The monitor stand rests flat, without feet; if placed over the vent, it would block the air flow.

The 25-page user's manual includes detailed instructions for connection, operation, use of controls, and troubleshooting, as well as specifications, pin assignments, signal levels, and timing charts. Warranty is one year for labor and two years for parts and picture tube.

NEC MultiSync XL

This $3195 unit measures 19 by 19 by 21 inches and weighs 57 pounds. Its screen measures 19 inches and has a medium bezel; it shows sharp reflections that are at-

continued

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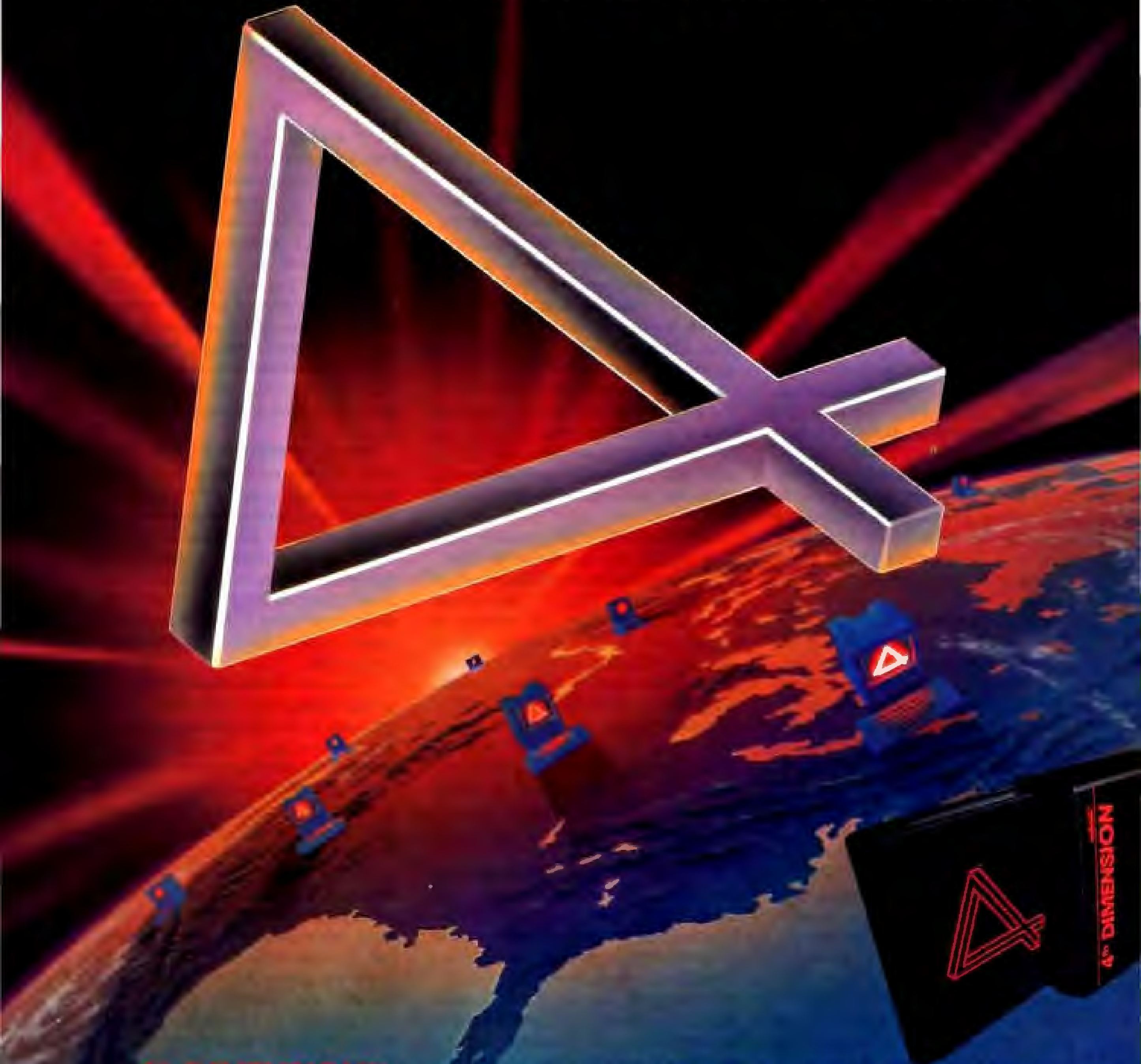

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patrick chédal C&C

BIX Product Focus: Multiscan Monitors

Computer monitors, like stereo speakers, are components that are most often judged subjectively. The pros and cons of different monitors are frequent topics, and the opinions here were all taken from the grafic.disp/displays conference on BIX. These comments are based on direct experience with the multiscan monitors in question.

For most people, the NEC MultiSync is still the basis of comparison. Most of the multiscan monitors fare pretty well, although the Sony Multiscan has disappointed several people.

—Curt Franklin, Technical Editor

PETE WHITE [petewhite]: "I picked up a Casper EGA monitor for my wife after finding it to be super. I think it's something like $600 with the board, if you look a bit—maybe even less mail-ordered. I couldn't go back to CGA, I know that."

MIKE GEARY [geary]: "Gack! Don't get an EGA-only display, whatever you do. It has to be the worst investment in town. One of the MultiSync-type displays is the only way to go, unless you want to pop for Zenith's lovely new FTM display.

"I saw a beautiful new MultiSync-type display the other day. It's made by Nanao. Never heard of the company before, but the display is much crisper than the NEC. [Nanao] makes two models, a 0.31- and a 0.28-mm dot pitch. The one I saw was the 0.31; same theoretical resolution as the NEC, but it just looked a lot better. The 0.28 ought to be even better than that."

KARL GUTTAG [karl.guttag]: "Regarding comparisons of multiscanning monitors, I've seen a lot of talk about color quality, but not a lot about linearity. A casual survey of the new multiscanning monitors seems to show a lot of curvature (pincushioning) toward the outsides of the tube. This curvature may be OK for TVs, but I find it annoying when dealing with high resolution. For example, I really like the relatively flat tube the Sony Multiscan has, but some of this advantage is lost due to some pincushioning. (I spent an hour with a Sony repairman trying to get the pincushioning out.) To be fair, the NECs I've seen are not much better."

MIKE GEARY: "The famous pincushioning problem.... I've seen that more times than I'd like in otherwise excellent displays. I don't like the Trinitron much for a display; the Sony Multiscan that we have at the office is kind of a dog. All the triad tubes I've used (NEC, Nanao) have been a lot better."

BRUCE WHEELOCK [wheelock]: "A few days ago, I was out looking at the NEC MultiSync and Sony Multiscan monitors, trying to make up my mind which one I'm going to buy. It happened that the guy working with the computer needed to switch the Sony off and then back on. When he did, there was a rather loud 'clacking' noise that sounded very much like mechanical relays. Is that the case?"

MIKE GEARY: "The clicking is indeed [caused by] relays in the Sony. When it switches scanning frequency, it uses mechanical relays to reconfigure some of the circuitry. The clicking is normal, and, in fact, I've come to like it on the Sony we have at the office. Unfortunately, the clicking is about the only thing I do like about the Sony. The NEC MultiSync I have at home beats it by a mile. Windows on the NEC looks so much better than Windows on the Sony, especially when you boost it to 640 by 480. Maybe we have an exceptionally bad Sony; I've seen some NECs that weren't too hot, either.

"There's a design problem with the Sony tube. The Trinitron stripes give a much higher resolution horizontally than vertically. This doesn't work too well with EGA and higher resolutions, which tend toward square pixels.

"The nicest display I've seen so far is the Nanao. It's a lot like the NEC but is crisper. These are all around the same price range, so I'd recommend either the NEC or the Nanao."

GARY THOMAS [gary.thomas]: "Of all the multiscan monitors I've seen—NEC, JVC, Taxan (made by JVC, I think)—the Sony is the worst.... Using mechanical relays to switch in-sweep circuitry may provide nice tactile feedback, but it is a damn primitive way of doing things, not to mention the life span of a relay.

"The Sony also requires you to change cables when switching from digital to analog, while the NEC switches the signals on the cable internally.

"I also haven't seen a Sony yet (and we have a lot of them) where you can turn the brightness up to a reasonable level without bringing the background blackness level up also. All in all, it seems to me that Sony kludged together a MultiSync before it really understood all the concepts, just to stay known in the market. I suspect sometime in the future we'll see a monitor from Sony designed well, as most of its stuff usually is, but until then, I'd suggest picking another brand."

BRUCE WHEELOCK: "On image alone, I found the Sony to have richer, deeper colors [than the NEC], but I didn't get a chance to play with the brightness and contrast controls to see what that would change. Character definition on both monitors seemed very nearly identical, but the Sony characters were flatter than I like; adjusting the height control on the monitor might change that.

"The use of mechanical relays and general engineering in the Sony worries me. One small engineering thing in the Sony struck me as very odd—the contrast and brightness controls (mounted on the side of the machine) work in the opposite direction of what you would expect. If you roll the control upward, it turns down the contrast...."

STEVE MACK [smack]: "For what this kind of anecdotal information is worth, my Sony lasted less than 1 solid week before developing odd symptoms, and it is now in for repair. It would not power up, some relay holding off AC internally when I turned it on. Eventually, it came back to life, then the display turned itself off while powered-up, with the typical clack of its relays. [The Sony is] nice visually, but I have a sense of foreboding about reliability...."

[Editor's note: *The BIX Product Focus presents a variety of informal, diverse opinions from users of a selected class of products. Messages selected for publication may be edited for length or clarity. The views expressed are those of each message's author and do not necessarily reflect those of BYTE or BYTE's reviewers.*]

tenuated so as not to be distracting.

Front panel controls include power, brightness, contrast, horizontal and vertical size and position, text mode, text color (green, amber, or white), input BNC/D-shell, and a degauss button. Back panel controls include an automatic/manual color set switch, a digital/analog switch, an 8/16/64 switch for manual color setting, and an input voltage selector. For signal input, the unit has a 9-pin D-shell plug (analog or digital signal) and four BNC plugs (analog signals). A tilt-swivel stand is included.

Bandwidth is 65 MHz, and resolution is up to 1024 by 768. Horizontal scanning rate is up to 50 kHz, and vertical scanning rate is 50 to 80 Hz.

We did not receive the monitor in time to test it with the Microvision equipment. In the Macintosh tests, the MultiSync XL performed similarly to the MultiSync Plus but was steadier on color blits.

Warranty is limited to one year for labor and two years for parts.

Princeton Graphic Systems Ultrasync

This $795 monitor has a 12-inch etched screen and measures 12 by 13 by 14 inches. The unit weighs 26 pounds. It comes with a tilt-swivel base.

Front panel controls are for brightness, contrast, text mode (green on black, amber on black, white on blue, or normal color display), and power. Rear panel adjustments are for horizontal/vertical size and position; switches are for underscan and overscan, 16/64 colors for use in digital operation, and digital/analog. A single 25-pin D-shell plug accepts digital or analog inputs.

Bandwidth of the Ultrasync is 30 MHz, and maximum resolution is 800 by 600. Scanning rate is up to 35 kHz horizontal and 45 to 120 Hz vertical.

The unit we received was damaged in shipping and could not be tested.

Documentation consists of a six-page folded brochure, including brief instructions for installation and operation, specifications, and pin assignments. The warranty is one year for parts and labor.

Sony Multiscan CPD 1302

This $945 monitor measures 12 by 14 by 17 inches and weighs 32 pounds. Its cylindrical 13-inch screen gives sharp reflections. The shallow bezel accepts light from nearby sources but does not cause shadows from overhead lights. The dot pitch on this monitor is 0.26 mm, the finest of all we included in this review.

Side panel controls (not visible while looking at the screen) are for power, contrast (adjusts all but intensity), and brightness (adjusts all). On the rear panel are controls for analog/digital select and horizontal/vertical position and size. Also on the rear panel is a mode switch for digital operation, selecting 8, 16, or 64 colors. A single 9-pin D-shell plug accepts digital and analog input.

Bandwidth of this monitor is 25 MHz. Maximum resolution is 900 by 560. Horizontal scanning rate is up to 34 kHz; vertical, 50 to 100 Hz.

In the SigmaVGA diagnostic test, the display showed some jitter when the nearby PS/2 monitor was turned on. Colors were close to those on the PS/2 monitor; the green was a little deeper, the brown was slightly less red than the PS/2's, and the white had a warm, paper quality. Yellows were less bright than on the PS/2 reference model.

In the 256-color palette test, the unit showed especially sharp definition between the various shades of colors across the spectrum. In the Macintosh tests, the monitor colors were excellent, though not quite so good as those on the Apple monitor. The display was very steady during color blits and disk accesses.

The 25-page English/French operating instructions included brief instructions for setup and use of controls, plus specifications and timing charts. A full warranty applies for 90 days; a parts and labor warranty applies for one year, two years on the tube.

Taxan Multivision 770 Plus

The $795 Taxan multiscan monitor measures 12 by 14 by 16 inches and weighs 31 pounds. Its 14-inch screen is etched, and reflections are diffused. The bezel is of medium depth.

On the front panel are brightness (adjusts all but intense colors) and contrast (adjusts all colors) controls. Rear panel controls include analog/digital; color/monochrome (for text-only display); preset auto/release and color select for autoswitching or 16 colors (CGA); scan size; and vertical size, vertical position, and horizontal position. There are also four sets of screw adjustments for vertical/horizontal position and size, one set for each of four frequency ranges; a plastic screwdriver is provided with the set. A 9-pin D-shell plug accepts analog and digital RGB inputs; a BNC plug accepts composite color video inputs.

The bandwidth of the 770 Plus is 30 MHz, and maximum resolution is 640 by 480. Horizontal scan rate is up to 35 kHz; vertical, 50 to 90 Hz.

During the Sigma tests of each mode, we had to adjust the horizontal size screws several times to keep the display a uniform size on the screen. A small amount of flicker was present; it went away when the nearby PS/2 monitor was turned off.

The unit showed excellent color purity on the 256-color palette test, and it was possible to see all 256 shades even on a low brightness setting (with most other monitors, brightness had to be increased somewhat to make all the shades visible).

The unit showed excellent colors in the Macintosh test, comparable to the Sony and Conrac. There was very faint fringing during hard disk access and some instability during color blits. Some pincushion distortion (contraction of the picture at the horizontal and vertical center lines and expansion at the corners) was also present.

The eight-page owner's guide explains setup and use of controls, pin-outs, and specifications. Warranty is limited to one year parts and labor.

Thompson Ultrascan 4375M

This $895 monitor measures 13 by 14 by 15 inches and weighs 28 pounds. It looks almost identical to the Mitsubishi AUM 1371A. The 13-inch screen is tinted and etched to reduce glare and diffuse reflections. The bezel is fairly deep, reducing the effects of nearby lights but also allowing shadows on the screen.

Front panel controls include power, brightness (changes all but high-intensity colors), and contrast (changes all colors). Rear panel controls include switches for selecting analog/digital/composite video, normal/monochrome, and underscan/overscan, as well as adjustments for tint and color (for use with composite color video input) and vertical/horizontal position and size. Separate inputs are provided for digital signals (9-pin D-shell plug), analog (25-pin D-shell plug), and composite video (BNC plug).

Flicker caused by interference from the nearby PS/2 monitor was noted. In the Sigma color tests, browns were truer (i.e., less red), reds were brighter, and white was bright.

Bandwidth of the 4375M is 30 MHz, and maximum resolution is 800 by 560. Horizontal scanning rate is up to 35 kHz; vertical, 45 to 75 Hz.

During tests with the Mac II, color was excellent. Very faint fringing was present during hard disk access. Color stability during color blits was good. We noted changes in the image size (ballooning and shrinking) as the contents of the screen changed. Some smearing or blurriness was noted along the top menu bar.

The 34-page English/French operating instructions included detailed instructions for connection and use of controls, specifications, special features (e.g., superimposition of images), troubleshooting, and timing charts. Warranty is limited to one year for parts and labor. ■

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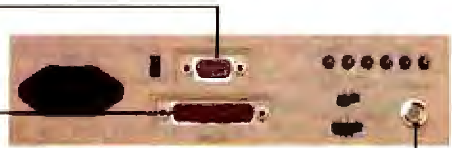

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Graphic Board Compatibility*

- ☐ Quadram QuadEGA ProSync
- ☐ Orchid Turbo EGA/Turbo PGA
- ☐ Sigma Designs Color 400
- ☐ Video 7 Vega-Deluxe
- ☐ QDP VIVA 640/800/1000
- ☐ Paradise Auto SW EGA
- ☐ STB EGA Multi Res
- ☐ Everex Micro Enhancer
- ☐ Hercules
- ☐ IBM VGA, PGC, EGA, CGA
- ☐ AST Research AST-3G/Model I
- ☐ ATI Graphics Solution/EGA Wonder

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Compaq Flexes Its Muscles

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The Deskpro 386/20 combines a new bus architecture with a faster processor

Compaq has always had a reputation for making high-quality, high-performance systems, but the company has surpassed all past efforts with the Compaq Deskpro 386/20. It is an AT-compatible system that uses a 20-MHz Intel 80386 CPU and Compaq's new Flex architecture—a combination of concurrent buses with 32K bytes of cache memory—to provide the highest level of PC performance yet. I love this machine.

The 386/20 comes in three basic configurations: the Model 60, the Model 130, and the Model 300. All have the same fundamental components: a 20-MHz 80386, 1 megabyte of memory, 32K bytes of cache memory, a 1.2-megabyte 5¼-inch floppy disk drive, a socket for either the Intel 80387 math coprocessor or the Weitek WTL1167 coprocessor board, one RS-232C communications port, one parallel port, and the Compaq enhanced keyboard. All three models also come with several useful programs, including the Compaq Expanded Memory Manager (CEMM) and a disk caching utility.

The only drawback to these systems is their cost. The Model 60 has a 60-megabyte, half-height, 2-to-1-interleave hard disk drive with a rated average access time of under 30 milliseconds. The system's suggested retail price is $7499. The Model 130 has a 130-megabyte, full-height, 1-to-1-interleave hard disk drive that runs off an enhanced small device interface (ESDI) controller and has a rated average access time of less than 20 ms. This model costs $9499. The top of the line is the Model 300, which includes a 300-megabyte ESDI hard disk drive and costs $12,499.

Those prices get you the basic systems. You will also want a monitor, a video controller card, and MS-DOS. Compaq's EGA-compatible color monitor and its Enhanced Color Graphics board will set you back $1198, and MS-DOS 3.3 adds another $120. That means that a 1-megabyte Model 60 with an EGA monitor and MS-DOS costs $8817. So few 20-MHz 80386-based systems are out now that comparable systems are hard to find. Nonetheless, you can get a PC's Limited 16-MHz system (with only a 40-megabyte hard disk drive) for $4799, while a 16-MHz Compaq Deskpro 386, also with a 40-megabyte hard disk drive, costs $6499.

My evaluation unit, a Model 300, was a good example of the high end of the 386/20 price range. It included almost every option Compaq offers: It had 6 megabytes of dynamic RAM (DRAM), a 20-MHz 80387 coprocessor, an additional RS-232C serial port and parallel port, the Compaq color monitor and Enhanced Color Graphics board, and a 135-megabyte tape backup drive. I also received Compaq's MS-DOS 3.31, along with the *Compaq Enhanced Color Graphics Board/Compaq Color Monitor Technical Reference Guide*. The tab for this: $21,421—or about 3½ Hyundai automobiles.

Performance and Compatibility

Just how fast is the Deskpro 386/20? The results of BYTE's standard benchmarks (see the box on page 118) indicate that the Deskpro 386/20 averaged about 50 percent faster than the IBM PS/2 Model 80 with its 16-MHz 80386.

I also ran the standard benchmarks with the cache memory controller enabled. The 32K bytes of cache made very little difference in the results. All the benchmarks showed a speed improvement of, at most, only $\frac{1}{10}$ second over runs without the cache. The cache memory controller would be most useful for computing jobs that read the same file or files repeatedly.

The only system that comes close in performance to the Deskpro 386/20 is Compaq's new Portable 386, which also uses the 20-MHz 80386. On all but one of the tests, the Deskpro 386/20 beat the Portable by margins ranging from 2 percent (on the Disk Write benchmark) to 100 percent (on the 40K File Copy); the two systems were even on the Spreadsheet Load test. The Deskpro 386/20 is clearly the fastest PC currently available.

It is also, as you would expect from Compaq, a highly AT-compatible sys-

continued

Mark L. Van Name (10024 Sycamore Rd., Durham, NC 27703) is a freelance writer and computer consultant.

Compaq Deskpro 386/20

Company
Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670

Components
Processor: 20-MHz Intel 80386; socket for 20-MHz Intel 80387 coprocessor or a Weitek WTL1167 coprocessor board
Memory: 1 megabyte of 100-ns DRAM on system memory board, expandable to 16 megabytes; 32K bytes of 35-ns static RAM (for cache); 128K bytes of BIOS ROM
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; 60-megabyte hard disk drive (Model 60), 130-megabyte hard disk drive (Model 130), or 300-megabyte hard disk drive (Model 300)
Display: Compaq color monitor; Compaq Video Graphics board
Keyboard: 101 keys in IBM enhanced keyboard layout
I/O interfaces: One RS-232C serial port (DB-9); one DB-25 parallel port; one RGBI monitor port (DB-9); one 32-bit expansion slot for system memory board; two 8-bit and five 16-bit expansion slots

Size
20 by 16½ by 6½ inches, 44 pounds

Software
Diagnostics test, system setup, ROM version, disk cache, and CEMM programs

Options
1-megabyte memory module: $549
4-megabyte memory module: $2099
4-megabyte system memory board: $2999
360K-byte 5¼-inch floppy disk drive: $225
1.2-megabyte 5¼-inch floppy disk drive: $275
1.44-megabyte 3½-inch floppy disk drive: $245
20-MHz 80387 coprocessor: $1199
Weitek coprocessor board: $1999
Compaq color monitor: $699
Compaq Video Graphics board: $599
Compaq dual-mode monitor: $255
Compaq video display controller board: $199
MS-DOS/BASIC 3.3 disks and reference guide: $120

Documentation
Compaq Deskpro 386/20 Personal Computer Operations Guide; Supplemental Software Guide; Compaq Disk Cache User's Guide

Price
Model 60: $7499
Model 130: $9499
Model 300: $12,499
System as reviewed: $21,421

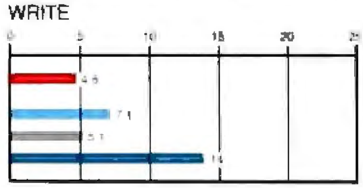
Inquiry 883.

Test	Compaq 386/20 80387-20	Model 80 80387-16	Compaq 386 80387-16	Compaq 386 80287-8	IBM PC AT 80287-8
Dhrystone*	5705	3626	3748	3748	1590
Fibonacci	38.27	57.26	53.11	53.12	126.22
Float	1.10	1.62	1.43	6.80	10.98
Savage	6.63	9.49	8.95	21.53	37.30
Sieve	3.88	6.45	5.98	5.99	24.60
Sort	4.89	7.74	5.58	5.58	43.17

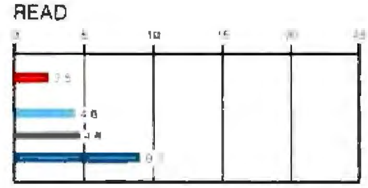
*For the Dhrystone test only, higher figures denote faster performance.

DISK ACCESS IN BASIC (IN SECONDS)

WRITE

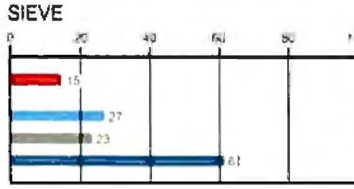


READ

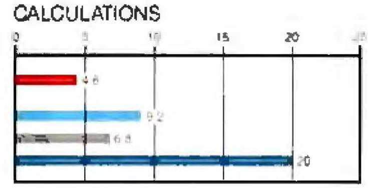


BASIC PERFORMANCE (IN SECONDS)

SIEVE

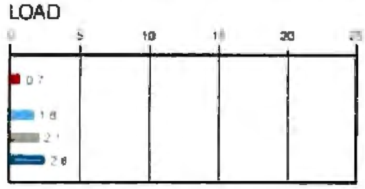


CALCULATIONS

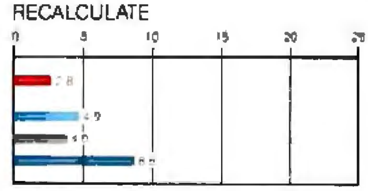


SPREADSHEET (IN SECONDS)

LOAD

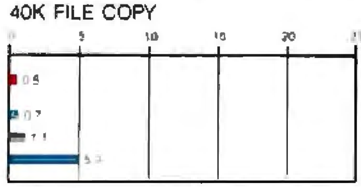


RECALCULATE



SYSTEM UTILITIES (IN SECONDS)

40K FILE COPY



COMPAQ 386/20 80387-20
IBM PS/2 MODEL 80 80387-16
COMPAQ 386 80387-16
IBM PC AT 80287-8

The table contains the results of the C language benchmarks (see "A Closer Look" by Richard Grehan in the September 1987 BYTE). All times are in seconds, except for the Dhrystone, which is in Dhrystones per second. The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.06) spreadsheet. The BASIC benchmark programs were run with MS-DOS 3.31 and GWBASIC 3.3 on the Compaq Deskpro 386/20. The IBM PS/2 Model 80 used PC-DOS 3.3 and BASICA 3.3. The Compaq Deskpro 386 used MS-DOS 3.1 and BASIC 3.11. IBM PC AT used PC-DOS 3.2 and BASICA 3.21.

tem. It ran everything I tested, and its documentation included a three-page, two-column listing of even more hardware and software that Compaq has tested. I ran the following programs: Lotus 1-2-3 version 2.0; Quarterdeck Office Systems' DESQview 2.0, with its Quarterdeck Expanded Memory Manager 386 version 1.10; Kermit 2.29C; The Norton Utilities 3.00; Microsoft PC Paintbrush 2.0; Symantec Q&A 1.1; Borland's Reflex 1.14, SideKick 1.56A, SuperKey 1.16A, Turbo C 1.0, and Turbo Pascal 3.0; Microsoft Word 4.0; MicroPro's WordStar 3.3 and 4.0; and Microsoft Windows 386 2.0. I also successfully installed two 16-bit memory cards (an Intel Above Board/AT and a Cheetah Card), along with an Everex Evercom II 2400-bit-per-second internal modem and a Microsoft serial Mouse.

Inside the Box

The 386/20 uses the standard Compaq desktop chassis. The cover is difficult to put on, both because it is a tight fit and because there are two tabs in the front that can be difficult to line up with the corresponding holes in the system.

Looking inside the system, you get the feeling that this is a "serious," complete computer: It looks as if Compaq's engineers assumed you would never need to open it. This contrasts with the design of the IBM PS/2 systems, which are intentionally easy to disassemble.

Inside the system, on the far left, is the 32-bit slot for use only by the system memory board; it holds all the machine's memory. It sits on a special 32-bit system memory bus. All the other slots reside on a standard AT-style bus (see photo 1).

The system memory board was designed by Compaq for this machine. It can hold either 1 megabyte (using 256K-bit chips) or 4 megabytes (using 1-megabit chips) of 100-nanosecond (ns) DRAM. The board can also hold up to three memory-module daughtercards of either 1 or 4 megabytes each. You can mix any combination of these configurations, up to the system limit of 16 megabytes. My unit had a 4-megabyte system memory board and two 1-megabyte memory modules.

To the right of the 32-bit slot is one 8-bit slot, which in my unit held the EGA board. There is another 8-bit slot on the far right, next to the power supply, but it is only half-height. My tape drive host adapter card sat there.

Between these two 8-bit slots are five full-size 16-bit slots. Two were empty in my system; the others held the ESDI hard disk controller board, the additional serial/parallel port card, and the Compaq Multipurpose Fixed Disk Controller Board. This controller board also controls the floppy disk drive and one serial and one parallel port. The power supply is a well-shielded 192-watt unit.

There are two disk drive bays on the front of the system. Each can hold two half-height or one full-height device. In my unit, the right bay held the full-height, 300-megabyte hard disk drive. The floppy disk drive was in the top of the left bay, and the tape drive was in the bottom. One nice touch was that two sheets full of useful system configuration information were glued to the top of the drive bay enclosure.

The system's motherboard is fairly small—14¼ by 9 inches—and, unlike many 80386 systems, does not use the Chips & Technologies support chip set. The board is divided into three distinct areas.

The first area, in the front left corner, is surrounded by a short metal radio-frequency-interference (RFI) shield. It holds the 80386 and 80387, as well as 13 other support chips. Both the 80386 and 80387 are socketed. All the sockets are labeled so you can easily insert the chips in the correct locations and with the correct orientations. The socket for the 80387 chip can also hold the Weitek WTL1167 coprocessor board, which sits on top of the fence and provides a socket for the 80387.

The second major area is to the right of the metal RFI shield and is also encased with a metal grill for RFI shielding. This area holds various support chips, the 20-MHz Intel 82385 cache controller chip, and the sixteen 16K- by 8-bit static RAM chips that compose the 32K-byte cache memory.

The rest of the motherboard contains the four power connectors for the disk drives, the power input from the power supply, and 46 chips that implement the system I/O, AT-compatible portion of the machine.

continued

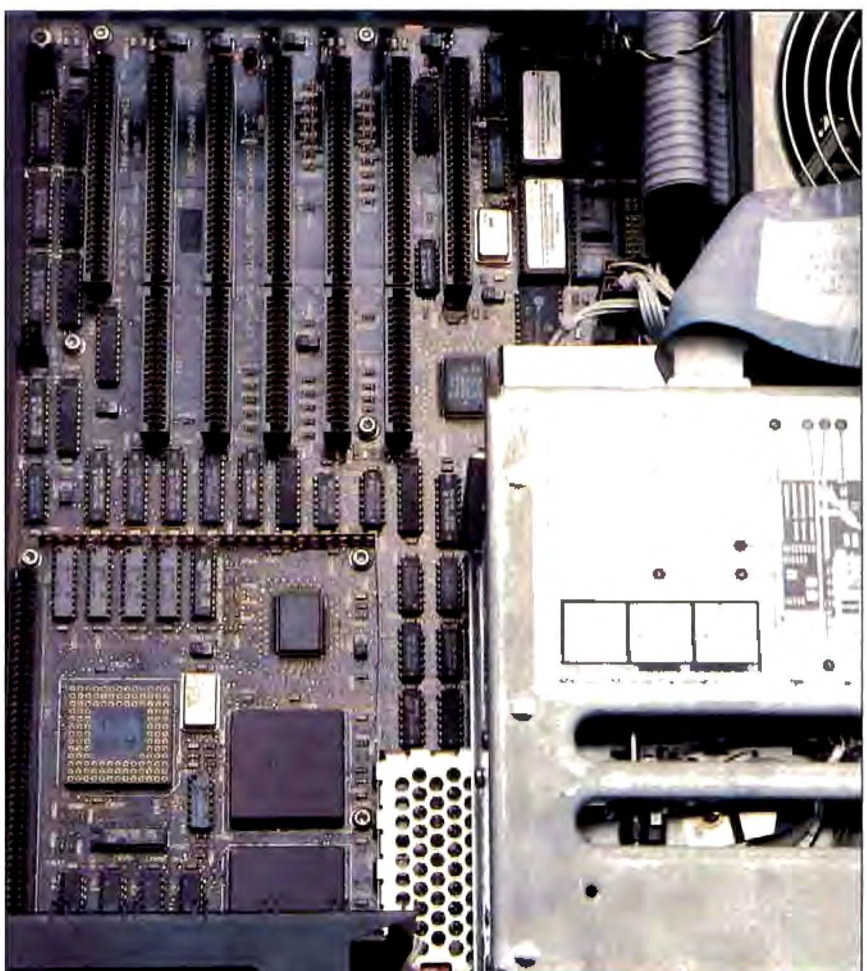


Photo 1: *Compaq Deskpro 386/20 motherboard. The system memory board connector is at the bottom left. The board features extensive radio-frequency-interference shielding. The perforated metal cover, at the bottom right beneath the floppy disk drive, covers the 32K-byte bus cache memory.*

The buses let the CPU get 32-bit memory even while a peripheral is accessing memory.

Flex Architecture and Performance

The Compaq Flexible Advanced Systems Architecture, or simply Flex architecture, combines concurrent memory and system buses with a memory caching scheme to improve system performance.

The concurrent buses let the CPU get 32-bit memory even while a peripheral is also accessing main memory. The 80386 CPU and the coprocessor (80387 or Weitek) sit on a local bus that is connected to the cache and the cache controller.

The basic principle of the cache is simple: The CPU gets its instructions and data from a small (32K-byte) area of very high-speed (35-ns) memory. As long as the data it needs is there (a hit), the CPU runs without wait states. If the data is not there (a miss), then the CPU waits while the data is retrieved from the slower (100-ns) DRAM system memory. If there is a coprocessor present, it also executes out of the cache.

The 82385 maintains the cache for those processors, retrieving needed data and flushing information that is no longer valid. Compaq claims that its cache will have a hit rate of 95 percent, so the CPU will wait very little. The 82385 also handles direct memory access (DMA) for the system; when a peripheral performs DMA, the 82385, not the CPU, is put into a hold state. The CPU can continue to run out of its cache while the 82385 handles the DMA.

The 82385 also performs "bus snooping" and implements posted write logic. Bus snooping is a process in which the 82385 monitors all DMA accesses to memory other than the cache. If it sees a change to any system memory that is also currently in the cache, it marks that cache data as invalid so that it will be replaced. In this way, the cache memory avoids any inconsistencies with the main system memory. The posted write logic allows the CPU to issue a memory write and then continue its work without waiting while the write is still being posted to the slower system memory.

In addition to communicating with the 80386 and the coprocessor on the local bus, the 82385 also has lines to the cache memory, the 32-bit memory bus, and a Cache Bus Interface (CBI). The CBI mediates between the 82385, the system memory board on the 32-bit bus, and the cards on the AT-compatible bus. In addition to expansion cards, the system ROMs, DMA controllers, and other I/O devices are on the AT-compatible bus.

As it does on its other 80386-based systems, Compaq also uses special logic on the Deskpro 386/20 to improve the performance of Compaq's ROM BIOS (version H.8). When the system starts, it copies the ROM BIOS to the 128K-byte area just below the 16-megabyte memory line. It then uses special hardware map registers to map all accesses to it from their normal ROM address to this new area in the 32-bit RAM.

The system also uses special hardware registers on the system memory board to write-protect the RAM that contains the ROM BIOS. This process speeds all accesses to the ROM BIOS, because the ROM chips are slow (250 ns) and sit on the slower AT-compatible bus. If the machine contains a Compaq Enhanced Color Graphics board, as mine did, the 16K bytes of EGA BIOS on the board are also copied into the same RAM area as the main system ROM BIOS.

Mass Storage

The floppy disk drive on the Deskpro 386/20 is a standard Mitsubishi 1.2-megabyte 5¼-inch unit. Compaq also sells a 360K-byte 5¼-inch floppy disk drive as well as a 1.44-megabyte 3½-inch floppy disk drive.

The 300-megabyte hard disk drive in my unit actually offered 315.3 megabytes of formatted storage. It was a Micropolis Model 1558-15 drive, Compaq BIOS type 38. It automatically parks the heads when the system is shut off. The drive is controlled by a half-height, 16-bit, ESDI controller card made by Western Digital. The 16K-byte buffer on the ESDI controller lets the drive run with 1-to-1 interleaving. According to the Coretest, the drive system had a data transfer rate of 781.7K bytes per second, an average seek time of 18.6 ms, and a track-to-track time of 6 ms.

With 300 megabytes of hard disk space, backup via floppy disks could be a nightmare. Fortunately, my unit included a 135-megabyte tape drive that used ¼-inch tape cartridges. The tape drive (Model 5150 EQ) and controller were made by Wangtek. Compaq also sells a 40-megabyte tape backup drive.

To run the 135-megabyte tape drive, you use a program called the SY-TOS Tape Operating System. It came with my system, along with a preliminary version of its user manual. At first, the drive and software hung the system. However, the software's troubleshooting chapter steered me in the right direction. The in-

continued

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terrupt and DMA settings that are standard with the software differ from those that are standard with the tape controller. Changing the settings in the program was simple, but this is a detail that Compaq should fix. [Editor's note: *Compaq says it will make those changes in the final version of the software.*]

Monitor and Keyboard

The monitor is the same EGA-compatible unit that Compaq has been selling for some time. It has a 13-inch screen and a tilt bar in the front. I used it with the Compaq Enhanced Color Graphics board. [Editor's note: *Compaq now offers a VGA-compatible Video Graphics monitor and controller board.*]

The Compaq enhanced keyboard that came with my system followed the format laid out by the 101-key IBM enhanced keyboard. The keyboard also has two legs so it can be tilted. The key action had good tactile feedback. As with other Compaq systems, the keyboard attached to a connector on the lower left front of the unit with a long coiled cord.

Software and Documentation

The Deskpro 386/20 includes a disk with user programs that provide many useful functions. Some of these you expect, such as a system test utility and a Setup program. There is also a disk cache program (CACHE) and Compaq's Expanded Memory Manager (CEMM), as well as a program to tell you the ROM version (ROMREV).

The `MODE` command has been enhanced to let you set the system's four compatibility speeds. The Auto speed lets the CPU run at full speed except when the floppy disk drive is active; the CPU then slows to the equivalent of an 8-MHz 80286 until the drive motor stops. This is especially useful for copy-protection schemes that are sensitive to CPU speed. The High speed runs the CPU at full speed all the time. The Fast speed simulates an 8-MHz 80286, while the Common speed acts as a 6-MHz 80286.

Compaq also included a copy of Microsoft's Windows 386 version 2.0 with my review unit. This program is designed to offer the look and feel of the presentation manager of OS/2. It uses the virtual machine capability of the 80386 to let each of several DOS applications run in its own 640K-byte area, as long as you have enough memory.

Compaq's version of MS-DOS can handle very large hard disks. It removes the 32-megabyte partition limit and allows partitions of up to 512 megabytes. My system's 300-megabyte hard disk drive had a 32-megabyte C partition, a 150-megabyte D drive, and a 150-megabyte E drive. This is a much needed and very welcome improvement to MS-DOS.

The documentation that comes with the system includes the *Compaq Deskpro 386/20 Personal Computer Operations Guide* and guides for installing and using the color monitor and the EGA board. You also get the *Compaq Disk Cache User's Guide* and the *Supplemental Software Guide*. As usual, the Compaq documentation is well written and thoroughly illustrated.

Support

The 386/20 comes with a one-year parts and labor warranty. Compaq is committed to selling through dealers, so all repairs and support must come from them.

I called two local Compaq dealers and asked them a fairly broad range of questions. They were unable to answer all but the very simplest ones. I tried the customer relations telephone number on the warranty card, but I was asked for my dealer's name, and the representative then offered to call my dealer for me. According to a Compaq spokesperson, if the dealer is unable to answer your questions, he or she is supposed to call Compaq, get the answers from the company's support staff, and then call you back.

My dealers did not want to follow this procedure, although I am sure it would have helped if I had bought my system from them. They freely admitted that they knew little about the Deskpro 386/20. Compaq said that this type of training delay is not uncommon; it takes some time after a new product is announced for Compaq's traveling trainers to teach all their dealers.

If you want service after the first year, you can buy Compaq's Extended Service Agreements for 12, 24, or 36 additional months. These agreements are expensive, however: A 12-month service agreement runs $519 for the Model 60, $579 for the Model 130, and $749 for the Model 300. Those costs cover only the basic system. You have to buy separate coverage for every option in your system, and this can really add up. For example, 12 months' service costs $99 for the 135-megabyte tape drive and $159 for the 4-megabyte system memory board. Like the system itself, support is expensive.

Power at a Price

The Deskpro 386/20 Model 300 is simply the fastest personal computer I have ever used. I want one. I even fantasized about stealing it, in large part because there is no way I can afford it. If you are on a budget, admire the 386/20 from afar. If you have the money to pay top dollar for top performance, right now there is nothing better. ■

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- debugger
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- utilities

Developer System $299
- all Standard System features
- UNIX utilities make, diff, grep
- UNIX vi editor

Commercial System $499
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- 6502 family
- 8080-8085-Z80-Z180-64180
- 8088-8086-80186-80286/8087-80287
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- download support

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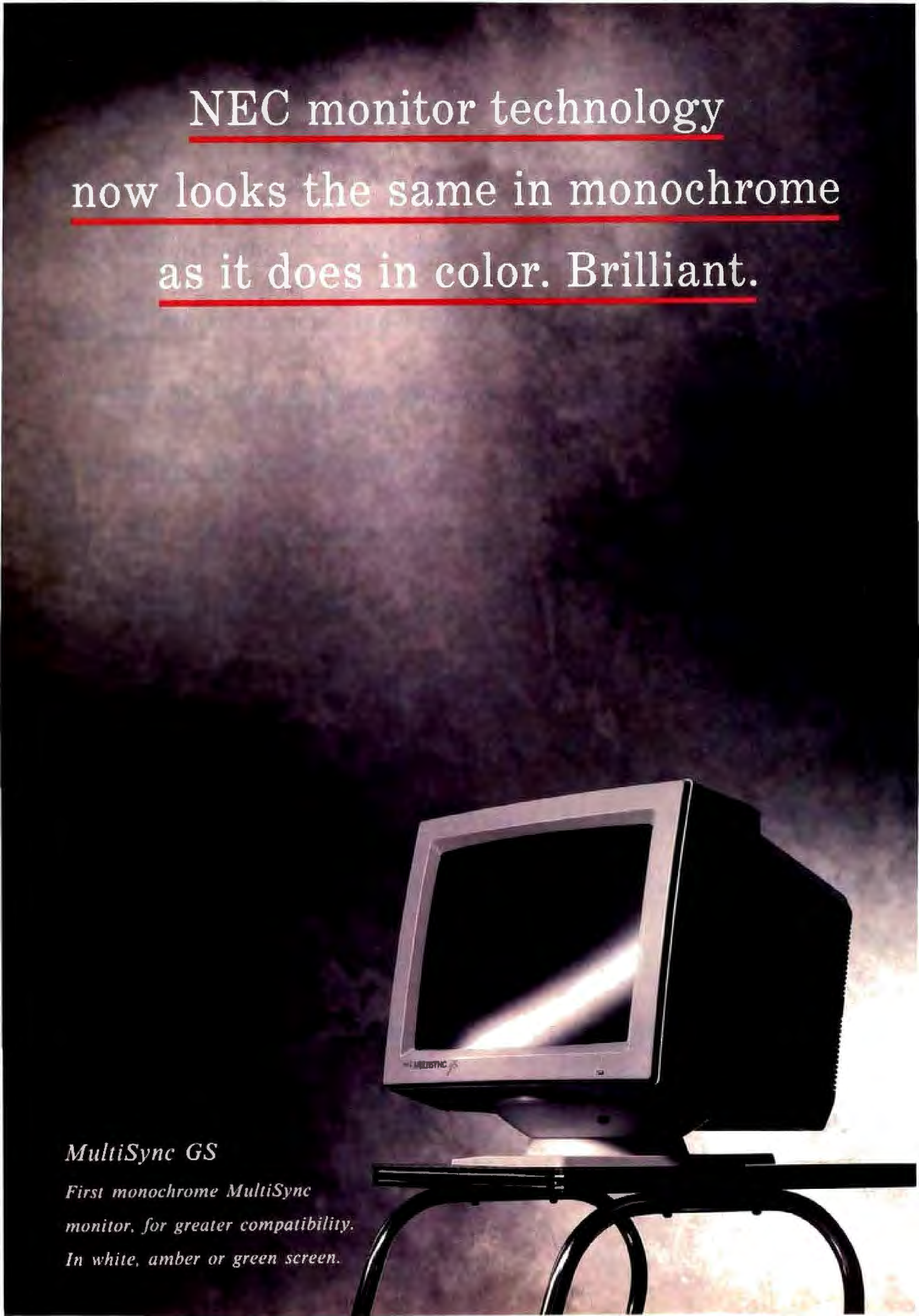
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The Tandy 4000

Mark L. Van Name

An AT-compatible system with a combination of high performance and extensive dealer support

The Tandy 4000 is an 80386-based, PC AT-compatible system that currently represents the top of the Tandy line of computers. Tandy has promoted it as an inexpensive system, citing a basic price of $2599. You can buy a unit for that price, but it includes only 1 megabyte of RAM and a 1.44-megabyte 3½-inch floppy disk drive. It does not include a hard disk drive, a disk controller, a video card, or a monitor, so a complete system costs substantially more.

The system I reviewed had a Tandy EGA-compatible monitor, an EGA card (the EGA Multi Res made by STB Systems), and an IBM-style enhanced keyboard. It contained 2 megabytes of 32-bit memory, a 1.44-megabyte 3½-inch floppy disk drive, a 40-megabyte hard disk drive, a combination floppy/hard disk controller card, a serial port/parallel port card, a system clock/calendar, battery-backed CMOS RAM for configuration data, MS-DOS 3.2, GWBASIC 3.2, Tandy's DeskMate II software, and several utility programs. This system costs $5977.

There are sockets on the motherboard for both a Weitek math coprocessor board and an 80287 math chip, but not for the 80387. I installed an 8-MHz 80287 math coprocessor, available from Tandy for an additional $399.95.

The 2 megabytes of memory in my system were divided into 640K bytes of user memory and 1 megabyte of extended memory. The remaining 384K bytes that fall between the 640K-byte and 1-megabyte boundaries are used to hold copies of the system's ROM BIOS and—when an EGA card is attached—the EGA BIOS. That memory can also be used by an expanded memory manager utility.

The Tandy 4000 is about 2¼ inches narrower and 1½ inches deeper than the standard IBM PC AT. It looks and feels sturdy. It has a power-on LED on the front panel, but it has no disk activity light. This minor omission can be annoying when you are trying to decide whether the system is working or hung. There is a keyboard lock on the front and a rocker-style power switch on the rear right side.

One flaw of the system is that it has only FCC Class A approval, not Class B, so it could cause some interference if used at home. A Tandy spokesperson said that the machine is intended for business use only and that Tandy has no plans to seek FCC Class B approval anytime soon.

Like the new PS/2 systems, the Tandy 4000 includes a 3½-inch floppy disk drive. While this is probably the wave of the future, it can be a problem for those with existing software on 5¼-inch floppy disks, especially when that software is copy-protected. Tandy does offer optional 1.2-megabyte and 360K-byte 5¼-inch floppy disk drives. It also provides a useful utility with which you can make either of the floppy disk drives appear to be drive A; this utility lets you buy an optional 5¼-inch floppy disk drive and use it for copy-protected software that demands to be in drive A.

Like other Tandy systems, the 4000 comes with a 90-day warranty. You can also buy a year of extended service that starts from the date of purchase. That service can be carry-in or on-site. The price for each type depends on the system configuration. For my evaluation unit, a year of carry-in service costs $474.75, and on-site service runs $893.25. If you live farther than 50 miles from one of Tandy's 60 U.S. service facilities, there is an additional fee for on-site service. Tandy estimates that these service facilities cover about 95 percent of the continental U.S.

If you have questions about using the system, you must contact your local Radio Shack Computer Center. The manuals don't list a telephone support number. I called four local Computer Centers with questions that ranged from very simple to fairly complex; no one at any store could answer any but the simplest of them. While the Tandy 4000 is admittedly a new system, this lack of understanding in the field could cause problems for novices. Some help is available from Tandy's optional Telephone Sup-

continued

Mark L. Van Name (10024 Sycamore Rd., Durham, NC 27703) is a freelance writer and computer consultant.

Tandy 4000

Company
Tandy Corp.
1800 One Tandy Center
Fort Worth, TX 76101
(817) 390-3700

Components
Processor: 16-MHz Intel 80386; socket for optional 8-MHz 80287 math coprocessor; socket for Weitek math coprocessor board
Memory: 1 megabyte of 100-ns dynamic RAM standard, expandable to 4 megabytes; maximum system memory is 16 megabytes
Mass storage: One 1.44-megabyte 3½-inch floppy disk drive; one half-height 40-megabyte hard disk drive (optional)
Display: EGA-compatible card (optional); EGA-compatible monitor from Tandy (optional)
Keyboard: 101 keys in IBM enhanced keyboard layout
I/O interfaces: One DB-9 serial port and one DB-25 parallel port; nine expansion slots; six 16-bit slots; two 8-bit slots; one 32-bit slot

Size
6½ by 19 by 16 inches; 47 pounds

Software
Disk formatting utility

Options
1-megabyte 32-bit SIMM add-on: $429.95
Memory-expansion board with 2 megabytes of 32-bit memory: $799
MS-DOS 3.20.03 (GWBASIC, DeskMate II, and utilities included): $99.95
Serial/parallel adapter: $149.95
Internal 1.2-megabyte 5¼-inch floppy disk drive: $299.95
Internal 360K-byte 5¼-inch floppy disk drive: $199.95
Monochrome monitor: $149.95
CGA monitor: $399.95
EGA monitor: $699
Monochrome/Hercules/CGA video card: $199.95
EGA video card: $299.95

Documentation
67-page *Tandy 4000 Installation and Operation Manual*; 28-page *Enhanced Graphics Adapter User's Manual*; 24-page *Tandy 3000 Hard Disk Controller Installation Manual*; 28-page *Tandy 3000 40-Megabyte Internal Hard Disk Drive Installation Manual*

Price
System as reviewed: $5977
Base system with a 20-megabyte hard disk drive: $3499
Base system with a 40-megabyte hard disk drive: $4299

Inquiry 984.

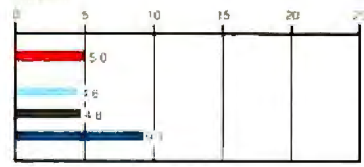
Test	Tandy 4000 80287-8	Model 80 80387-16	Compaq 386 80387-16	Compaq 386 80287-8	IBM PC AT 80287-8
Dhrystone*	3589	3626	3748	3748	1590
Fibonacci	55.56	57.26	53.11	53.12	126.22
Float	7.28	1.62	1.43	6.80	10.98
Savage	22.52	9.49	8.95	21.53	37.30
Sieve	6.21	6.45	5.98	5.99	24.60
Sort	7.87	7.74	5.58	5.58	43.17

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

DISK ACCESS IN BASIC (IN SECONDS)

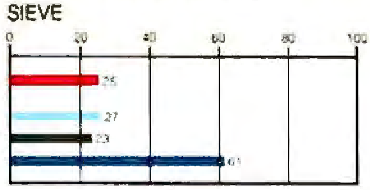
WRITE

READ

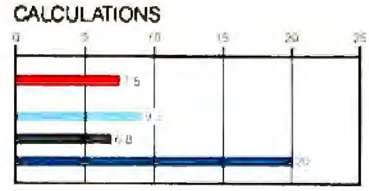


BASIC PERFORMANCE (IN SECONDS)

SIEVE

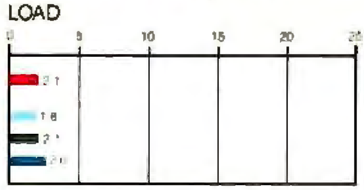


CALCULATIONS

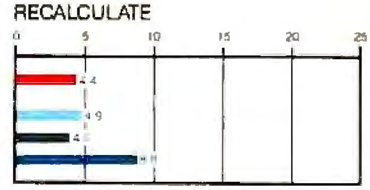


SPREADSHEET (IN SECONDS)

LOAD

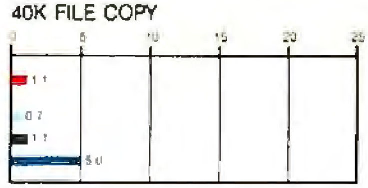


RECALCULATE



SYSTEM UTILITIES (IN SECONDS)

40K FILE COPY



TANDY 4000
IBM PS/2 MODEL 80
COMPAQ DESKPRO 386
IBM PC AT (8 MHZ)

The table contains the results of the C language benchmarks (see "A Closer Look" by Richard Grehan in the September 1987 BYTE). All times are in seconds, except for the Dhrystone, which is in Dhrystones per second. The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.06) spreadsheet. All BASIC benchmark programs were run with MS-DOS 3.20 and GWBASIC 3.20 on the Tandy 4000; PC-DOS 3.3 and BASICA 3.3 on the Model 80 and PC AT; and Compaq DOS 3.1 and Compaq BASIC 3.11 on the Deskpro.

port: for $60, you get help on six "incidents," even if each requires several calls to resolve.

Performance and Compatibility

Speed is perhaps the most important aspect of the new 80386-based systems. The tables at left show the Tandy 4000's times for the standard BYTE C and BASIC benchmarks running on my evaluation unit with an 8-MHz 80287 math coprocessor.

I compared the Tandy 4000's results with those of the Compaq Deskpro 386 running at 16 MHz with an 8-MHz 80387. The Tandy 4000 lost to the Compaq on all the tests except the Spreadsheet Load and 40K File Copy, on which the two machines were about even. It was usually less than 10 percent slower, but its times were much worse on the Disk Write (30 percent slower) and the Sort test (29 percent slower).

The Write and Sort results can be attributed to the differences in the disk drives on the two systems. The Compaq's hard disk drive and hard disk controller card have a data transfer rate of 235.6K bytes per second, an average seek time of 26.4 milliseconds, and a track-to-track seek time of 4 ms, according to the Coretest. The Tandy 4000's hard disk system has a data transfer rate of 160.8K bytes per second, an average seek time of 30.6 ms, and a track-to-track seek time of 3.9 ms.

The Compaq also uses faster memory: 80-ns RAM, as compared to the Tandy's 100-ns RAM.

I also ran BYTE's standard benchmarks with a disk cache of 128K bytes in extended memory, using Tandy's CACHE utility. I timed both the first run and then several more runs of each test so I could see any initial cost of the cache, as well as any benefits that came from repeated accesses to the same files.

The cache had little impact on the C benchmarks. The BASIC Calculations and Sieve benchmarks and the Spreadsheet Recalculate test were also largely unaffected. However, the Write, Read, 40K File Copy, and Spreadsheet Load benchmarks all ran from 5 percent to 50 percent faster with the cache on. The greatest speed increase came after the first run, once the cache was "primed" with the desired data. If you do much work that involves repeated accesses to the same few files, Tandy's disk cache utility could prove helpful.

Compatibility with the IBM PC AT is the other crucial issue for new systems. All the software I tried worked with the Tandy 4000. I tested the following products: DESQview 2.0 (with Expanded Memory Manager 1.10), Kermit 2.29C, Lotus 1-2-3 1.0, The Norton Utilities 3.00, PC Paintbrush 1.0, Q&A 1.1, Reflex 1.14, SideKick 1.56A, Smalltalk/V 1.2, SuperKey 1.16A, Symphony 1.2, Turbo C 1.0, Turbo Pascal 3.0, Microsoft Windows 1.01, Microsoft Word 3.10, and WordStar 3.3 and 4.0. Symphony was copy-protected, but the Tandy 4000 handled it automatically.

I successfully installed several hardware options as well, including a Cheetah Card (with 2.5 megabytes of 120-ns memory), an Evercom II 2400-bit-per-second internal modem, an Intel Above Board/AT, and a Microsoft serial Mouse. I had some trouble getting the Microsoft serial Mouse to work, so Tandy sent me a new serial/parallel adapter card. That did not solve the problem, so I upgraded my mouse driver software to Microsoft's newest version, 6.1. It then worked.

According to Tandy, the company's engineers discovered that the problem was due to a noisy system bus that was causing the mouse driver to check for a bus mouse even though I was using a serial mouse. To avoid this problem, you can use the /C1 (or /C2, for serial port 2) option of the Microsoft mouse driver to force it to ignore the bus and check only the designated serial port. That option is not present, however, on some older mouse drivers. With its MS-DOS, Tandy ships a mouse driver (version 6.0) that includes this option.

A Peek Inside

The Tandy 4000 provides a 192-watt power supply that can operate at either the U.S. standard of 115 volts and 60 Hz or the European 230 V and 50 Hz. Standard expansion peripherals are supported through a 16-bit, 8-MHz AT-compatible bus. This bus has six 16-bit and two 8-bit expansion slots. In my evaluation computer, one 8-bit slot was occupied by Tandy's serial/parallel adapter card, and two of the 16-bit slots were used by the EGA adapter and the disk controller card.

The motherboard, which was designed by Tandy, measures about 11 by 16 inches. It can hold either 1 or 2 megabytes of 32-bit memory, and the optional memory-expansion board provides an additional 2 megabytes of 32-bit memory. Each megabyte consists of four single inline memory modules (SIMMs). Each SIMM contains nine 256K-byte 100-ns dynamic RAM chips, so there is parity checking. When 1-megabyte SIMMs become more commonly available, the motherboard will be able to hold 8 megabytes.

The CPU accesses the memory on the motherboard and on the memory-expansion board, if one is present, through a proprietary 32-bit bus. The memory-expansion board plugs into a single 32-bit slot that is designed to support only this board. The length of the connector for that slot is about halfway between the length of a standard 8-bit connector and that of a standard 16-bit connector. The connector is divided into two identical halves.

The motherboard has sockets for the Weitek WTL1167 board and an 80287 coprocessor.

The Tandy 4000 motherboard also has sockets for both the Weitek WTL1167 math coprocessor board and an 80287 coprocessor. The Weitek socket gets scant mention in the Tandy documentation. Tandy does not offer the Weitek board as an option, but it may do so in the future. The Weitek socket cannot be used with the 80387 math coprocessor. [Editor's note: *The Weitek WTL1167 math coprocessor board is available for the Tandy 4000 from MicroWay (P.O. Box 79, Kingston, MA 02364, (617) 746-7341) for $1495. Installing this board requires soldering a jumper on the Tandy 4000 motherboard. This would invalidate your warranty.*]

Architecture

Like many 80386-based systems, the Tandy 4000 uses the support chip set from Chips and Technologies (C&T). The C&T 82C302 memory controller implements an interleaved, or bank-switched, memory architecture. This approach assumes that programs tend to access memory sequentially. It groups memory into pairs of banks and then alternates memory locations between the two banks in a pair. Once a bank has been accessed, it has time to be refreshed without slowing the CPU if its paired bank is used in the next access. When this is true, there are no memory wait states. There are also no wait states when a second memory access is not sequential but is still seeking an address in the other bank in the pair.

The 82C302 chip places several constraints on the possible memory configurations. First, it views memory as either one, two, or four banks and allows no other options. The chip also requires that each pair of banks contain identical components. This is why the allowable Tandy 4000 memory configurations are 1, 2, or

continued

4 megabytes with the current SIMMs. If Tandy eventually introduces SIMMs that use 1-megabyte chips, then the system's 32-bit memory could go as high as 16 megabytes: four banks of 4 megabytes each.

One extremely important consequence of this implementation is that the system does not interleave memory if you have only a single memory bank. Thus, the standard 1-megabyte system loses this performance edge and runs with wait states. This means that the standard system will run slower than is implied by my benchmark results for the 2-megabyte system.

This architecture and its performance improvements apply only to the 32-bit memory. You can also put additional memory, up to the system maximum of 16 megabytes, in the 16-bit slots, but it will run considerably slower than the 32-bit memory.

The Tandy 4000's 80386 CPU runs at 16 MHz. You can change it to a compatibility speed of 6 MHz with a DOS `SPEED` command. You can also set the speed to `AUTO`, in which case the CPU runs at 16 MHz except during disk accesses, when it switches to the slower speed. This is particularly helpful when you are using copy-protected software. The Tandy 4000 slows the CPU by using the C&T 82C301 timing chip to set the system's oscillator to 12 MHz instead of its usual 32 MHz.

The BIOS (version 1.03.01, dated 8/6/87) was done by Phoenix Technologies and is compatible with the IBM BIOS. At start-up, the Tandy 4000 speeds ROM accesses by copying the ROM into part of the 32-bit memory between the 640K-byte and 1-megabyte boundaries. If an EGA board is present, the Tandy 4000 also copies its ROM into that area.

Disk Drives

There is one disk drive bay on the right front of the unit. It can hold three half-height devices or one half-height and one full-height device. In my evaluation unit, the top slot was occupied by a 1.44-megabyte 3½-inch floppy disk drive. The middle slot was empty. The bottom one contained Microscience International's model HH-1050 hard disk drive—a half-height, 5¼-inch, 40-megabyte drive with 1024 cylinders and 5 heads. The drive was already physically formatted, but I had to partition and logically format it using Tandy's `MLPART` and `MLFORMAT` utilities.

The disk controller handled both drives. It uses standard Western Digital chips and has cabling for up to two floppy disk drives and two hard disk drives.

Monitor and Keyboard

Tandy offers both monochrome and EGA monitors. My unit came with the Tandy 13-inch Enhanced Graphics Monitor EGM-1. I was immediately struck by how big it was: It weighs over 30 pounds and measures 15¾ inches wide by 12¾ inches high by 15½ inches deep. It has no legs, swivel supports, or other positioning options. It has an unusual control button that lets you toggle the text characters between white and green. The screen display of characters was crisp, and the color was good.

The EGA card is from STB Systems. It can support either a CGA or an EGA monitor. It also has an IBM-compatible light-pen connector. The Tandy 4000's keyboard follows the IBM enhanced keyboard style. It has 12 function keys across the top and has indicator lights on the upper-right corner for the Num Lock, Caps Lock, and Scroll Lock keys. It has a soft but audible keyclick. The key action is a bit soft for my taste, but overall the keyboard has a pleasant feel.

Software and Documentation

The basic system comes with only utility software for such tasks as disk formatting. However, Tandy has made several very nice additions to its version 3.2 of MS-DOS. One is a disk cache utility, which is becoming increasingly common on 80386-based systems. There is also a program, MON386, that uses extended memory to let you have up to nine applications in memory at once. This program is limited in functionality and can't compete seriously with such programs as Windows or DESQview. It allows a maximum of only 512K bytes per program, for example, and I had trouble getting it to run WordStar 4.0 and BASIC at the same time.

Other useful additions include an expanded memory manager (TEMM), a file compression/decompression utility (DC), a disk optimizer (DISKOPT), the speed control command discussed earlier, and fast file backup (FBACKUP) and restore (FRESTORE) commands.

The Tandy 4000 also comes with DeskMate II, a standard Tandy product that provides many of the desktop management functions of such popular products as SideKick. It contains six applications, all of them simple and bare-bones: a text editor, a spreadsheet, a file-card system, a communications program, a calendar, and a mail system. It also includes on-line help, a calculator, and an alarm, as well as a menu that provides access to common MS-DOS functions like file renaming and deletion. While many of these applications are useful and you cannot beat the price, none compete well with stand-alone products that offer the same functions.

My evaluation unit included a hefty stack of manuals. There were two fairly standard reference books, the *Tandy 3000 BASIC Reference Manual* and the *Tandy 3000 MS-DOS Reference Manual*. DeskMate II has a separate manual. I also received 11 smaller pieces of documentation. (For a partial list, see the box on page 130.)

While many of the books were obviously intended for Tandy's 3000 system, material specific to the Tandy 4000 was covered well in the installation and MS-DOS enhancement manuals. The various hardware installation manuals were clear, but they typically assumed that you at least knew what a jumper was and why you might need to set one.

Generally, the books were readable and easy to use. My only complaint is that there were so many of them that it was sometimes difficult to find desired information. For example, when I wanted to study Tandy's MS-DOS additions, I checked the MS-DOS manual and then the handbook, and had no luck in either one. The book that covered the enhancements had been buried in the DeskMate II binder because the other binder was full. This problem seems to stem from Tandy's use of the same books for several different systems.

Yet Another 80386 System

The Tandy 4000 is a solid AT-compatible, 80386-based system. It is by no means the fastest of the top systems. It is also not one of the cheapest. A system like my evaluation unit but with only one megabyte of 32-bit memory ($429.95) costs $5548. By contrast, a similarly equipped unit from PC's Limited costs $4899, while a similar Compaq Deskpro 386 with a monitor lists for $7298.

The Tandy 4000's speed and price make it a reasonable system, but not an exceptional one. Once Tandy's many Radio Shack Computer Centers have more information on and experience with the 4000, its biggest strength may be that huge support network. ■

Datavue's Spark and Snap 1+1

by Alex Lane

Price and portability distinguish these two laptops from the competition

For a laptop microcomputer to succeed in the market, it must stand out from the burgeoning competition. Datavue, maker of the widely known Datavue 25 laptop, is attempting to break away from the crowd with two laptops, the Spark and the Snap 1+1.

The main selling point for the Datavue Spark is its price, which stands at just under $1000 for a base unit with a 9.54-MHz NEC V20 processor, 384K bytes of memory, and one floppy disk drive. The distinguishing feature of the Snap 1+1 (which also has a 9.54-MHz NEC V20 processor) is its ability to be separated into two parts for increased portability. Suggested price for the Snap 1+1, in its basic configuration, is $2295.

Nine-Pound Portables

The two units occupy approximately the same 13- by 13-inch footprint. The Snap 1+1, however, is approximately a half inch thicker than the 2½-inch thick Spark. The cases are made of plastic, and they carry stickers warning the user not to place excessive weight on the machine to avoid destroying the disk drives. The Snap 1+1 displays additional warnings related to LCD screens and connecting screws.

When the front and back of the 9-pound Snap 1+1 are separated, the modem, reset button, both serial and parallel ports, display, keyboard, and optional RAM disk come away with the 4-pound front unit, called the Lap Module. The rear unit holds the floppy disk drives, the 640K-byte main memory, and a single expansion slot that can accept a half-height graphics, communications, or network card (see photo 1).

You can operate the Snap 1+1 from either of two types of AC adapter power supplies (SP-PS1 or SP-PS2) or from a nickel-cadmium battery; when operated independently, the Lap Module can operate from either an SP-PS2 power supply or a nickel-cadmium battery that comes with the optional 512K-byte CMOS RAM memory expansion. The battery will allow the Lap Module to run for about 6 hours. If left unattended, a separated Lap Module will maintain files in its RAM drive for about a month before the batteries give out.

You can operate the Spark from either the SP-PS2 AC adapter or internal nickel-cadmium batteries. The batteries will power the Spark for 3 to 4 hours on a full charge.

One 720K-byte 3½-inch floppy disk drive is standard in the 9-pound Spark, and it can be fitted with an additional internal 3½-inch drive. The Snap 1+1 has two 3½-inch floppy disk drives standard; one of these can be replaced with a 20-megabyte hard disk drive.

Both units come equipped with RGB and composite plugs for external CGA monitors, as well as a port for the Datavue external 5¼-inch floppy disk drive. The Snap 1+1's peripheral ports are along the sides on the front Lap Module; all the Spark's ports are in the back of the machine. The Spark and Snap 1+1 both have sockets for 8087 coprocessors.

The Datavue Snap 1+1 (left) and Spark are 9-pound laptops with full-size keyboards and a choice of displays.

Keyboards

The keyboards of both the Snap 1+1 and the Spark have a good, springy feel to them, with plenty of tactile feedback. The Spark has a 77-key keyboard that provides 10 function keys, 4 cursor keys, and a standard QWERTY layout. The Enter key and the left and right Shift keys are larger than those on an IBM PC; as a result, some of the less frequently used characters, such as the Alt and \ keys, have been displaced.

My only complaint about this keyboard is that you have to use the Function key to enable the Home, PageUp, PageDown, and End key functions, as well as to enable an embedded numeric keypad in the alphabet part of the keyboard.

The Snap 1+1 comes with an 84-key keyboard; it fits a QWERTY keyboard and a separate numeric keypad into a

continued

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small area. For space-saving reasons, some compromises here were, of course, inevitable. Major departures are the PrintScreen key, which is placed in the lower left corner, and the Insert and Delete keys, which are under the right Shift key, separated from the numeric keypad. The Shift keys and the Enter key are comfortably oversized, and the function keys are arranged horizontally across the top of the keyboard.

One feature of the Datavue machines that you would probably never discover without the documentation is the ability to change many machine parameters using the left-Shift-Control key combination. Simultaneously pressing the left Shift, Control, and *T* keys, for example, displays a Help screen that explains some of the other things you can do. Most of these things are quite useful, like controlling the cursor shape, turning backlighting on and off, toggling between an internal and external B drive, and toggling between the Spark's 4.77- and 9.54-MHz clock speeds.

Keying left-Shift-Control-R turns the Snap 1+1 into a dumb remote terminal, even if the machine hasn't booted DOS. I found this feature to be useful when you need a terminal immediately and can't wait for disks to spin or software to load.

A Choice of Screens

Both machines have a nonbacklit supertwist LCD; electroluminescent (EL) backlit screens are available as options. In addition, the Snap 1+1 can sport an amber fluorescent gaslight screen.

Of the three screen types, the nonbacklit LCD consumes the least power but is also the hardest on your eyes. The price difference between the nonbacklit display and the EL screen is $125 for the Spark and $100 for the Snap 1+1. The gaslight screen, with red lettering on an amber background, costs an extra $200 for the Snap 1+1. In my book, the nonbacklit LCD is a poor third choice for either machine.

All three screens are 80 columns by 25 rows, 640 by 200 pixels, and measure 9½ by 4½ inches; they are fully adjustable for contrast. The amber gaslight screen has an additional control for brightness, but I didn't notice much difference from maximum to minimum brightness settings. A selection of screen palettes (toggled sequentially using an arcane key manipulation) didn't offer much of a selection on either the EL or gaslight screens; I never could get full- and half-intensity to show up well together on the same screen.

Documentation

Two manuals come with each machine. One is a generic *MS-DOS Manual* that, judging from the names of all three Datavue laptops on the cover, accompanies all machines. The second book is a well-indexed operations manual for the specific machine.

The *MS-DOS Manual* has some nasty omissions, like failing to mention the /5 switch for the FORMAT command, which is necessary if you're going to work with an external drive or with the RAM drive in the Snap 1+1. Information about the /5 switch is in the operations manual. Thus, it's best not to depend exclusively on any one book for these machines.

Snap 1+1

Company
Datavue Corp.
One Mecca Way
Norcross, GA 30093-2919
(404) 564-5668

Components
Processor: NEC V20 running at 9.54 MHz; socket for 8087 numeric coprocessor
Memory: 640K bytes of RAM
Mass storage: Two 720K-byte 3½-inch internal floppy disk drives
Display: Nonbacklit supertwist LCD, 80 columns by 25 rows, 640 by 200 pixels, 9½ by 4½ inches
Keyboard: 84 keys, 10 function keys, numeric keypad
I/O interfaces: RS-232C 25-pin serial port; parallel port; external bus (for disk); RGB video; composite video
Power: AC adapter; nickel-cadmium battery (3 to 4 hours fully charged)

Size
13 by 13 by 3 inches; 9 pounds

Software
MS-DOS 2.11 version 1.20; Datavue diagnostics

Options
EL backlit LCD display: $100
Fluorescent gaslight LCD display: $225
Small AC adapter: $95
Large AC adapter: $200
512K-byte RAM expansion: $795
5¼-inch external floppy disk drive: $495
20-megabyte internal hard disk drive: $1200
Battery: $60 (small); $99 (large)
Modem: $325
Case: $75

Documentation
280-page *MS-DOS Manual*; 73-page *Snap 1+1 Operations Manual*

Price
Basic unit: $2295
With EL backlit LCD: $2395
With fluorescent gaslight LCD: $2495
With 20-megabyte hard disk drive: $3495
With 20-megabyte hard disk drive and EL backlit LCD: $3595
With 20-megabyte hard disk drive and fluorescent gaslight LCD: $3695

Inquiry 885.

Spark

Company
Datavue Corp.
One Mecca Way
Norcross, GA 30093-2919
(404) 564-5668

Components
Processor: 8-bit NEC V20, with speed keyboard-switchable between 4.77 and 9.54 MHz; socket for 8087 numeric coprocessor
Memory: 384K bytes of RAM, expandable to 640K bytes
Mass storage: One 720K-byte 3½-inch internal floppy disk drive standard
Display: Nonbacklit supertwist LCD, 80 columns by 25 rows, 640 by 200 pixels, 9½ by 4½ inches
Keyboard: 77 keys, 10 function keys, embedded numeric keypad
I/O interfaces: RS-232C 9-pin serial port; parallel port; external bus (for disk); RGB video; composite video
Power: AC adapter; nickel-cadmium battery (3 to 4 hours fully charged)

Size
13 by 13 by 2½ inches; 9 pounds

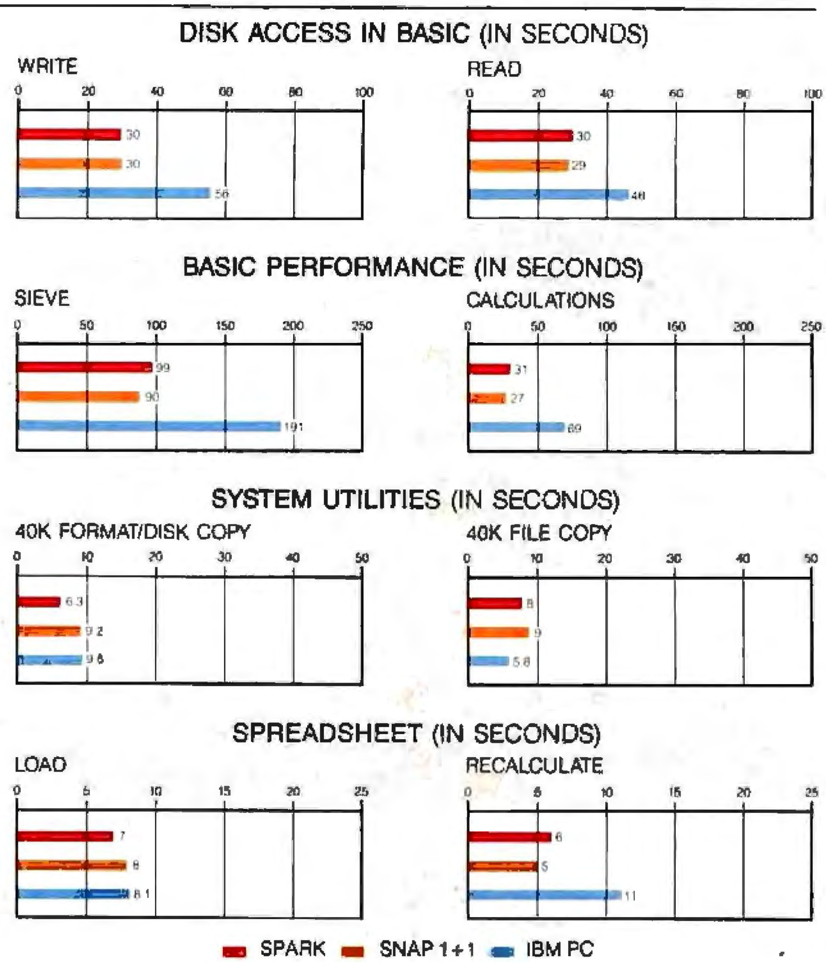
Software
MS-DOS 2.11 version 1.20; Datavue diagnostics

Options
Additional 3½-inch floppy disk drive $200
EL backlit screen: $125
256K-byte RAM expansion: $130
5¼-inch external floppy disk drive: $495
Battery: $60 (small); $99 (large)
Internal 300-/1200-bps modem: $325
Case: $75

Documentation
280-page *MS-DOS Manual*; 57-page *Spark Operations Manual*

Price
Basic unit: $995
With two floppy disk drives, 640K bytes of RAM, and EL backlit LCD: $1450

Inquiry 886.



The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet tests load and recalculate a 25-row by 25-column Multiplan (1.10) spreadsheet. All BASIC benchmark programs were run with MS-DOS 3.10 and GWBASIC 3.0.

Unfortunately, some of the information in the *Snap 1+1 Operations Manual* is incorrect. For example, the Setup screen displays shown in the Start-Up section only vaguely resemble what actually comes up on the computer screen. More seriously, the procedure for setting up the RAM drive to allow the Snap 1+1's Lap Module to boot automatically leaves out a crucial step. Despite these errors, the operations manual for the Snap 1+1, like the operations manual for the Spark, is a valuable piece of documentation.

Accessories

Installing things like modems, screens, and memory cards with these machines shouldn't be much of a hassle if you've done similar operations with other equipment. The documentation that comes with the machines whizzes through the installation process. I encountered no difficulty performing any installations, with the minor exception of the phone jacks for the modem, which were a tight fit.

The 5¼-inch external floppy disk drive measures 6¼ by 9¼ by 3½ inches and comes with a separate power cord and data cable. The on/off switch is in the back of the unit, along with a plug that allows other equipment (like a computer's power supply) to be connected; thus, you use only one wall plug. In operation, the external drive is physically always the B drive. Although the external drive is not heavy, it is bulky; I didn't enjoy traveling with the complete kit of computer and drive.

The internal 300-/1200-bit-per-second modem available for both machines conforms to the Bell 212A standard and is Hayes-command compatible.

Support

It takes a little effort to dig up Datavue's phone number, since it's not prominent in the documentation. When I first called, I was told the support staff was in a meeting and was asked if I would care to leave my number. I declined, and I called again later. Again, nobody was available to speak with me. This time, I relented and left my name and number. My call was returned in about 2 hours. I spoke with a fairly knowledgeable support person who made some valuable suggestions to help me out of a bind I was experiencing with the Snap 1+1. Although it was annoying to have to wait for a callback, I found the support to be professional and courteous.

Performance Differences

Both machines were run through the standard BYTE benchmarks, including the BASIC Disk Access and system Performance benchmarks, as well as the System Utilities and Spreadsheet Load/Recalculate tests.

In the tests that measure calculating power (BASIC Performance and Spreadsheet benchmarks), the Spark and the Snap 1+1 performed nearly identically, with the Snap 1+1 showing a slight advantage in most tests. Of the remaining benchmarks, the only surprising result was the slowness with which the Snap 1+1 performed the 40K Format/Disk Copy function. Where the Spark requires about 6 seconds to format and copy 40K

continued

Photo 1: *The Snap 1+1 separates into the rear Expansion Module (left), containing disk drives, 640K bytes of main memory, and a half-card expansion slot; and the front Lap Module (right), which, with an optional RAM expansion card, can be used as a lightweight, RAM disk-based portable machine.*

bytes of data, the Snap 1+1 requires more than 9 seconds.

In the Real World

The machines got a real-life workout as I commuted with one or the other to work daily and on business trips. I quickly found it advisable to come up with some sort of carrying case for the Spark, because the disk drive openings are exposed to the world when in transit. Datavue offers a carrying case for the Spark, though one was not included with the review computer.

I ran a variety of software on both machines, including Chessmaster 2000, Framework II, Turbo Prolog 1.1, WordStar 3.3, and WordPerfect Executive 1.0, all with no problems. Since the screen aspect ratio of these laptops differs from that of most CGA monitors, graphics images tended to be flattened: Squares appeared as rectangles; circles appeared as ellipses.

The Spark is an easy machine to like, aside from the minor keyboard annoyances noted previously and having to carry a 9- to 25-pin serial adapter cable. It performed like a champ on the road (including a couple of airplane trips). In particular, I found the blue-on-white EL screen to be pleasing to the eye. I also found an unexpected benefit of running off the AC adapter with the Spark: If AC power fails (which happens a lot in Florida), the batteries, if fully charged, keep your programs and data from evaporating for between 3 and 4 hours. I didn't find this to be the case with the Snap 1+1, where anything more severe than a voltage dip would kill the machine.

Using the Snap 1+1 was a frustrating experience. The first unit I received began to corrupt disk files at random, and

continued

 Circle 219 on Reader Service Card

the left-hand drive kept insisting that all of a particular brand of disk were write-protected when, in fact, they were not. When a replacement unit arrived, I found that it would not boot from the left-hand (A) drive, even though it passed all but one of the drive diagnostics provided by Datavue as part of the system software. The balky diagnostic was the disk format test, which failed with a `Format Error` message about one time out of three.

In addition to the disk problems, and despite its nice keyboard, I found that the Snap 1+1 has too many other quirks and "gotchas" to make it worth using. For example, the Lap Module cannot be used as a separate unit unless it has the 512K-byte CMOS RAM memory card ($795) installed. Also, if you're going to use the Lap Module with an AC adapter, you need to get a different power supply (not the one supplied with the Snap 1+1). Finally, once the Lap Module is separated from the expansion unit, the screen backlight cannot be turned on for either the EL or the gaslight screen.

Even the disk-access LED is implemented with more style in the Spark than in the Snap 1+1. With the Snap 1+1, the disk access light can glow only green, showing only that a drive is being accessed. By contrast, the Snap has a two-color LED that glows red when the left-hand drive is being accessed and green when the right-hand drive is being accessed.

Thumbs Up, Thumbs Down

The benchmark results and my subjective feeling for the performance of these machines place them squarely in the "average" category of laptop. The only feature of either machine that elicited a mild "Hey! That's neat!" reaction was the left-Shift-Control key combinations.

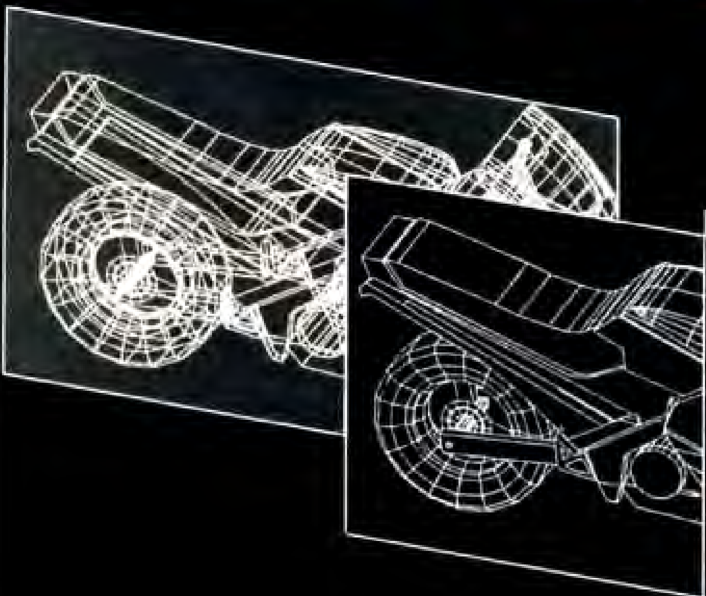
The Spark is your basic laptop. I somehow can't help but think "Volkswagen Bug" when I think of the Spark. The 9.54-MHz mode is nice to have and will make large spreadsheets recalculate faster, but it doesn't much help the performance of word processors or other programs that spend most of their time waiting for user input.

The Snap 1+1's modularity didn't impress me, partly because I personally don't have use for it (I always need disk drives), and partly because repeated separation and mating of the two halves of the machine make the multipin connector between the units a likely candidate for failure.

The Datavue Spark accomplishes what its designers set out to do: Come up with an inexpensive yet full-featured DOS laptop. The Snap 1+1, however, falls short not in concept, but in execution. ■

DesignCAD 3-D

3-D CAD You Can Afford



DesignCAD 3-D is a complete 3-Dimensional CAD system. It compares favorably with systems costing more than $3000! But, in the great American tradition, we said "Aw . . . What the Heck! Let's see the other guys beat this!" DesignCAD 3-D is $299. Complete.

Once again, American Small Business Computers has proved that you don't always have to spend a lot of money to get quality software. DesignCAD 3-D provides features such as Shading, Hidden Line Removal, Printer and Plotter support, and extensive file transfer capability, all for $299! No other 3-Dimensional CAD system can come close to providing the price/performance of DesignCAD 3-D.

There is a very important reason to buy DesignCAD 3-D other than price: PERFORMANCE. DesignCAD 3-D provides complete 3-Dimensional drawing capabilities. It's not a "warmed-over" 2-D program. DesignCAD 3-D allows you to draw any entity in 3-D space. This means, for example, that you can draw a curve in the shape of a spring. You can draw a circle or arc at ANY angle on ANY plane.

DesignCAD 3-D allows up to 4 simultaneous views - any angle or perspective - on the screen. DesignCAD 3-D also provides complex extrusions - linear, scalar, and circular. Extensive 3-D text capabilities and auto dimensioning are provided - at no extra charge, of course.

DesignCAD 3-D provides the capability to read drawings from most other CAD systems (DesignCAD/ProDesign II, AutoCAD's DXF, and IGES file formats). You can also send a view of a 3-D drawing to other CAD systems. These features are included at no extra charge, of course.

DesignCAD 3-D almost certainly is compatible with the computer system you now own. DesignCAD 3-D supports more than 200 dot matrix printers, at high resolution. DesignCAD 3-D supports more than 80 plotters, and most digitizers and graphics adapters available for "PC Compatible" systems. Shaded and wireframe models can be output to the printer or plotter YOU own.

DesignCAD 3-D does not require expensive graphics adapters and monitors - even shading can be done on ordinary displays such as the Enhanced Graphics Adapter (EGA), Color Graphics Adapter, or Hercules monochrome adapter.

However, the best reason to buy DesignCAD 3-D is not the low price. It's not the outstanding performance. It's not the extensive hardware compatibility. The best reason to buy DesignCAD 3-D is for its amazing ease of use!

DesignCAD 3-D provides powerful commands you can use to produce professional 3-Dimensional drawings in less time than you thought possible! DesignCAD 3-D commands can be selected from the menu or entered as fast, single keystroke commands. We have found DesignCAD 3-D to be easier to learn and easier to use than any 3-Dimensional CAD system for the IBM PC, at any price!

What else do you need to know about DesignCAD 3-D? Only this: "Included at No Extra Charge." What is included at no extra charge? EVERYTHING! $299 BUYS IT ALL!

How do you get one?

See your local dealer, or contact:

American Small Business Computers, Inc.
118 South Mill Street
Pryor, OK 74361
(918) 825-4844
Telex 9102400302

Circle 10 on Reader Service Card

Micro Channel Memory Boards

Jonathan Shiell, Bud Smith, and Curtis Franklin Jr.

These boards offer up to 8 megabytes of memory for the PS/2 Models 50 and 60

The IBM PS/2 Model 50 and Model 60, with their focus on the OS/2 operating system, need more memory than their standard 1 megabyte. The Micro Channel Architecture (MCA) bus used by the PS/2 family differs dramatically from the IBM PC bus, and users have had to wait several months for third-party vendors to introduce add-in boards for the new bus. Now, the first wave of 16-bit Micro Channel memory boards has arrived.

We installed and tested the IBM PS/2 80286 Memory Expansion Option, Everex RAM II 2000, Orchid RAMQuest 50/60, Quadram QuadMeg PS/Q, Everex RAM II 4000, AST Advantage/2, and Cumulus CuRAM on a PS/2 Model 50 and on a Model 60. There are problems and shortcomings, but, as a group, the boards worked well. Their varying capabilities and prices give the owner of a Model 50 or 60 a wide range of choices.

Points of Difference

Major issues to consider when comparing MCA-compatible memory boards are:

• *IBM memory board ID compatibility.* Every board for the Micro Channel bus has a unique ID number that is used in the software configuration of the board and bus. Boards with 2 megabytes of RAM or less can use the same ID number as the IBM memory board, and these are easy to configure at installation time. Boards that can hold more than 2 megabytes cannot use IBM's ID number, and, due to the way the PS/2s handle memory boards, they have a more complicated configuration procedure.

• *Capacity.* The amount of memory and other functions that can fit on a given board is an important consideration for Model 50 users, who have only three available slots.

• *OS/2, EMS, and EMS 4.0 compatibility.* All the boards can function as extended memory and, therefore, will work with OS/2. Most are Expanded Memory Specification (EMS) 4.0-compatible; the AST board has no EMS capability, while the Cumulus board offers both EMS and enhanced EMS (EEMS). This allows maximum software compatibility until more EMS 4.0 products are announced. [Editor's note: *For more information on the Lotus-Intel-Microsoft (LIM) EMS 4.0 specification, see "High-Speed Memory Boards for ATs" by Barry Nance in the December 1987 BYTE.*]

• *Added programs.* Utility software for RAM disks and print spoolers is included as a standard feature with every board except the IBM PS/2 80286 Memory Expansion Option. The RAM disk and disk-caching programs provided with the Models 50 and 60 can also use the additional memory.

• *Speed.* For one-wait-state performance, the PS/2 Models 50 and 60 require RAM chips fast enough to respond within a 300-nanosecond (ns) window. The 150-ns, 120-ns and 100-ns chips used by the boards we tested all meet this requirement.

• *Cost.* The boards range in price from $849 for a fully populated, 2-megabyte Everex Ram II 2000 up to $4170 for an AST Advantage/2 with 8 megabytes of RAM and an I/O daughterboard. Both initial cost and cost of upgrades are important. Upgrade cost is affected by the type of memory the boards use. The Everex boards use commonly available socketed dual in-line package chips (DIPs). Most of the other boards use single in-line memory modules (SIMMs), which are specialized daughterboards that have higher packing density but are more expensive than DIPs—in a given

Two-megabyte Micro Channel memory boards: (left to right) the Everex Ram II 2000, Orchid RamQuest 50/60, and IBM PS/2 80286 Memory Expansion Option. All use the same Micro Channel ID number.

amount of board spacing, more bits for more bucks. In either case, memory upgrades are available from the manufacturer or on the open market. The Cumulus board uses a custom daughterboard available only from Cumulus.

The Tests

We installed and tested all the boards in both a PS/2 Model 60 and a Model 50. We used DESQview version 2.0 to check EMS and EEMS capability; IBM's disk-cache and VDISK programs from PC-DOS 3.3 tested extended memory access. All the boards worked to specification.

The main problem we had was in following the instructions for installing and configuring the boards that hold more than 2 megabytes of RAM; all required several more configuration steps than did the 2-megabyte boards. Less experienced users who follow the instructions might actually have an easier time here than "experts" who are too impatient to read the directions.

Up to 2 Megabytes

The 2-megabyte boards are functionally very similar. Like most PS/2 boards, they are "plug and play": Plug the board in, run the automatic configuration, and get to work. They hold up to 2 megabytes of RAM, with no other functions, and all use the IBM ID to identify themselves to the PS/2 Power-On Self-Test (POST) and configuration programs. The 2-megabyte boards we tested are as follows:

• *IBM PS/2 80286 Memory Expansion Option.* This board is IBM-compatible by definition, and it's easy to install. It doesn't come with any software, so you have to rely on the IBM VDISK and disk-caching programs. IBM does not advertise that this board is EMS-compatible, but it is. IBM even sells an EMS driver for the board, but you have to buy the 3270 Emulation package ($475) to get it.

The 80286 Memory Expansion Option comes with 512K bytes of 120-ns RAM standard. Additional RAM is added via 80286 Memory Expansion Kits (small daughterboards with 512K bytes of memory), up to a maximum of 2 megabytes. The kits cost $165 each. The board we tested was populated with 1.5 megabytes of RAM.

A small gripe: Few of the boards are clearly labeled, but the IBM board stands out for giving as few clues as possible as to its manufacturer or purpose. (The proprietary RAM chips do say IBM on them.)

• *Everex RAM II 2000.* The RAM II 2000 is EMS 4.0–compatible and includes RAM-disk and print-spooler software. The Everex boards are sold as bare boards; the 1-megabit, 120-ns memory chips are available separately from Everex. At $399 for the board itself and $450 for 2 megabytes of RAM, the board costs $849—less than any of the other boards reviewed here.

Installing the RAM II 2000 is simplicity itself. By using the IBM memory expansion board's ID, Everex lets the IBM automatic configuration software do all the work.

• *Orchid RamQuest 50/60.* The Orchid is EMS 4.0–compatible. Software shipped with the RamQuest 50/60 includes a RAM disk, disk cache, and print spooler. This board features complete documentation, including a useful *Quick Installation Card.* The RamQuest 50/60 costs $995 with 2 megabytes of RAM.

When the IBM configuration software looked at these three boards, it saw three identical pieces of hardware. Thus, when

continued

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(Left to right) The Cumulus CuRAM, AST Advantage/2, Quadram QuadMeg PS/Q, and Everex Ram II 4000. Each of these offers more than 2 megabytes of add-in RAM for the Micro Channel bus.

Name	PS/2 80286 Memory Expansion Option	RAM II 2000	RamQuest 50/60	QuadMeg PS/Q
Type	2-megabyte Micro Channel memory board	2-megabyte Micro Channel memory board	2-megabyte Micro Channel memory board	Switchable 2/4-megabyte Micro Channel memory board
Company	IBM Corp. Information Systems Group 900 King Street Rye Brook, NY 10573 (800) 447-4700	Everex 48431 Milmont Dr. Fremont, CA 94538 (415) 498-1111	Orchid Technology 45365 Northport Loop W Fremont, CA 94538 (415) 683-0300	Quadram One Quad Way Norcross, GA 30093-2919 (404) 564-5566
Size	Standard Micro Channel board	Standard Micro Channel board	Standard Micro Channel board	Standard Micro Channel board
Features	Extended memory; EMS-compatible (no drivers provided); up to 2 megabytes with three Memory Expansion Kits installed	EMS 4.0-compatible, RAM-disk software, print-spooler software	EMS 4.0-compatible; RAM-disk software, print-spooler software; disk-cache software	EMS 4.0-compatible, RAM-disk software, print-spooler software, switchable between 2-megabyte IBM memory board ID and 4-megabyte Quadram ID
Options	IBM 512K-byte Memory Expansion Kit, $165	None	None	None
Documentation	None	36-page *User's Manual*	*Quick Installation Card*, 16-page *Software Guide*; 8-page *Support Guide*	60-page *User's Manual*
Price	With 512K bytes: $549 With 1 megabyte: $714 With 2 megabytes: $1044	With 0K bytes: $399 With 2 megabytes: $849	With 2 megabytes: $995	With 0K bytes: $395 With 512K bytes: $545 With 2 megabytes: $1095 With 4 megabytes: $1995
	Inquiry 887.	**Inquiry 888.**	**Inquiry 889.**	**Inquiry 890.**

we put all three boards in the Model 50, the system showed a total of 6.5 megabytes of RAM.

Over 2 Megabytes

The boards in this group all share one problem: The IBM configuration program does not automatically handle memory boards with a capacity greater than 2 megabytes. The CMOS RAM that holds the total memory currently in the system is not updated correctly on installation; that is, non-2-megabyte RAM boards are ignored in calculating the total. Larger-capacity boards must be assigned to memory spaces above any 2-megabyte boards. The over-2-megabyte boards we tested all have IBM-assigned ID numbers, but because of the configuration problem, steps in addition to the IBM auto-configure program are required. If you buy one of these, follow the installation instructions carefully.

In order of increasing capacity, the 2-megabyte boards we tested are:

• *Quadram QuadMeg PS/Q* (which is a 2-megabyte memory board using the first switch setting, and a 4-megabyte board using the second switch setting). This board is unique among the boards we tested, because it ignores one of the principal design features of the Micro Channel. The Micro Channel is designed to allow all boards to be software configurable; with time, switches and jumpers should fade to a dim memory. With this in mind, the set of three jumpers on the main board and the large toggle switch on the back of the PS/Q is surprising.

In theory, the switch helps users: If 2 megabytes of memory or less are installed on the board, the switch allows the PS/Q to use the IBM memory expansion ID, thus simplifying installation for the user. If more than 2 megabytes are installed, the board is switched to another ID, and a slightly more complex configuration follows. In practice, the large unlabeled switch makes physical installation of the board more difficult (it bumps into the back of the case). Other board makers (such as Everex, AST, and Cumulus) have found ways to solve the configuration problem without violating the principle of the Micro Channel.

Our board had 2 megabytes of 120-ns RAM installed. With the exception of an erroneous statement in the instructions (one set of directions for setting the switch position is reversed), the board configured easily and worked well. The QuadMeg PS/Q is EMS 4.0-compatible and includes RAM-disk and print-spooler software. However, because of the switch and jumpers, we couldn't help feeling that this board was the least attractive solution to the memory upgrade problem.

• *Everex RAM II 4000* (4-megabyte capacity). The Everex RAM II 4000 offers extended memory and EMS 4.0 compatibility; you can have both types of memory sharing the board simultaneously. This lets you mix DOS, EMS, utility programs, and OS/2. The board can hold either 2 megabytes or 4 megabytes of 120-ns memory. Utility programs include a RAM disk and a print spooler.

Everex provides configuration software that lets you choose between a number of memory configurations and I/O addresses. While this provides maximum flexibility for a knowledgeable user, the

RAM II 4000	Advantage/2	CuRAM
4-megabyte Micro Channel memory board	8-megabyte Micro Channel memory board	2- to 8-megabyte PS/2 memory board
Everex 48431 Milmont Dr Fremont, CA 94538 (415) 498-1111	AST Research Inc. 2121 Alton Ave. Irvine, CA 92714-4992 (714) 863-1333	Cumulus Corp. 180 Basswood Cleveland, OH 44022 (216) 247-2236
Standard Micro Channel board	Standard Micro Channel board	Standard Micro Channel board
EMS 4.0-compatible, RAM-disk software; print-spooler software	RAM-disk software; print-spooler software; connector for I/O board	EMS 4.0-compatible; EEMS-compatible; RAM-disk software; print-spooler software; connector for I/O board or 2400-bps modem
None	I/O daughterboard with serial and parallel ports: $175	I/O daughterboard with serial and parallel ports: $149 2400-bps modem: $445
48-page *User's Manual*	78-page *User's Manual*, 100-page *Software Guide*; 30-page *Software Installation Supplement*	29-page *User's Manual*
With 0K bytes: $499 With 2 megabytes: $949 With 4 megabytes $1399	With 512K bytes: $495 With 1 megabyte: $695 With 2 megabytes: $995 With 4 megabytes: $1995 With 8 megabytes: $3995	With 2 megabytes: $995 With 4 megabytes (two 2-megabyte daughterboards): $1590 With 4 megabytes (one 4-megabyte daughterboard): $1995 With 8 megabytes: $3490
Inquiry 891.	**Inquiry 892.**	**Inquiry 893.**

number of choices makes the installation and configuration processes among the most complex of the reviewed boards.

At $499 for the bare board and $900 for 4 megabytes of RAM, the total cost of $1399 makes it the least expensive per megabyte of any board we tested.

• *AST Advantage/2* (8-megabyte capacity). An easy-to-use custom installation procedure takes the place of IBM's, but, because of the way the installation works, this board cannot coexist with any future boards that may need their own configuration programs. The Advantage/2 worked well in the same system with other memory boards tested here.

The AST board is the only board we tested that provides extended memory but not expanded (EMS) memory. The Advantage/2 memory board can be upgraded in 512K-byte increments, using various combinations of 256K-byte and 1-megabyte SIMMs, from 0.5 megabyte up to 8 megabytes. The Advantage/2 has a zero-wait-state mode, which is not helpful with the current PS/2 Models 50 and 60 (both use one wait state), but which may give a speed advantage with coprocessor boards or future PS/2 systems.

Utility programs provided by AST include a RAM disk and a print spooler. Documentation for the Advantage/2 and for the utility software is complete and well written.

The board has a connector for an I/O daughterboard, making it well worth considering for Model 50 users. Prices of $995 for 2 megabytes, $1995 for 4 megabytes, and $3995 for 8 megabytes put it at the high end in price.

• *Cumulus CuRAM* (8-megabyte capacity). The Cumulus CuRAM holds up to 8 megabytes of RAM, which can be used as extended, EMS 4.0, or EEMS memory (this is the only board we tested that is EEMS-compatible).The Cumulus CuRAM comes with a print spooler; the DOS VDISK driver is used to set up a RAM disk. There is also an emulator that lets expanded memory act as extended memory; this is useful for switching back and forth from OS/2 to DOS-with-EMS. The documentation is good, going so far as to explain the difference between extended and expanded memory.

The CuRAM holds two memory modules, each either 2 or 4 megabytes. The only complaint we have with this board is that a 2-megabyte (150-ns) module and a 4-megabyte (100-ns) module cannot coexist on the board. This means that the user who purchases the board with a 2-megabyte module cannot upgrade by adding a 4-megabyte module; the 2-megabyte one must be removed first.

In spite of the complications of upgrading memory, the CuRAM is a powerful board. In addition to a full complement of memory, it can support an I/O board with one serial and one parallel port ($149) or a 2400-bit-per-second (bps) modem ($445). The availability of add-ons and the high capacity of the board make the CuRAM a choice worth considering for the Model 50. With 2-megabyte daughterboards, a 2-megabyte board costs $995 and a 4-megabyte board costs $1590. Using 4-megabyte daughterboards, a 4-megabyte board costs $1995 and a full 8-megabyte board costs $3490.

Picking a Board

First, the good news: All the boards we tested work, and work well. Furthermore, the most complicated installation and configuration process we saw here is much less complicated than the installation of the average PC-bus memory board.

Now, the bad news: There is little to differentiate most of the boards, especially in the under-2-megabyte category.

Among the 2-megabyte boards, the Everex RAM II 2000, at $849, is the least expensive. The Orchid ($995) and IBM ($1044) boards do exactly the same thing at greater cost. Any of the boards will work with the PS/2s, but the owner of a Model 50 should look seriously at a board that provides more memory in a single slot.

There is greater difference among the more-than-2-megabyte boards. The Everex RAM II 4000, at $1399, is the cheapest way to get to 4 megabytes of memory. The AST Advantage/2, at $3995, is the most expensive way to get to 8 megabytes, and it provides the 8 megabytes without including EMS support. The Cumulus CuRAM ($3490 for 8 megabytes) provides support for every expanded memory scheme we know of. Finally, the QuadRAM QuadMeg PS/Q ($1995 for 4 megabytes) has a design that stresses low-hassle software configuration at the cost of violating the spirit of the Micro Channel.

In the end, the only clear winners are the Everex RAM II boards. If your memory needs are straightforward and cost is your main criterion, the Everex boards come out ahead of a high-quality group of memory boards. ■

A Quintet of WORMs

Wayne Rash Jr.

At first glance, the write once, read many (or WORM) optical disk drive looks like the answer to the microcomputer user's prayers. You can store over 200 megabytes on some of them, the disk is removable, and nothing can be erased. You can't lose anything. But WORM drives may not be for everyone; not everybody needs absolutely permanent archival storage at a cost that exceeds that of an equivalently sized hard disk drive.

The IBM 3363 ($2950), Optotech 5984 ($2950), Franklin FLD 200 ($4600), N/Hance 525 ($2950), and Maximum Storage's Maximum Systems APX-3200 ($2675) are all WORM drives designed to work with the IBM PC and compatibles. Like Information Storage's WC 525 optical disk drive, reviewed in the July 1987 BYTE, two of the drives reviewed here are made by ISI: the N/Hance and the Maximum Storage units. Optotech makes the drive marketed under its own name and also the one marketed by Franklin. IBM won't tell who makes the 3363.

What's in a WORM?

The WORM drives that I examined have many similarities: Each is mounted in a separate external chassis with a built-in power supply, and each connects by a cable to a controller designed for the IBM PC bus. Each drive is also available in a version that can be mounted inside the computer in the space for a full-height 5¼-inch floppy disk drive.

Installing any of the units involves inserting the controller card into your PC, running a cable from the card to the drive, and installing the software (by adding lines to your CONFIG.SYS file, and so on)—a process that is generally performed by an installation program.

Superficially, the 5¼-inch media for these units resemble larger versions of 3½-inch floppy disks. They are in plastic cases with metal shutters. If you slide the shutter aside and look at the disk (which you're not supposed to do), you will see that they resemble a compact disk, except that you can see through them faintly. You cannot interchange disks between manufacturers, although I was able to interchange them between drives made by the same manufacturer but different OEMs. The IBM unit and the Optotech-manufactured units hold 200 megabytes of data per side, while the ISI-manufactured drives hold 120 megabytes per side. All the units accept single or double-sided disks, except for the IBM unit, which uses only single-sided disks.

Despite the fact that only three manufacturers are represented in the five drives reviewed here, these machines show surprising differences. Each of these companies developed its own software and firmware, and each decided the way its product would function. Accessing 200 megabytes requires that the developer make modifications to MS-DOS, since MS-DOS can't access anything larger than 32 megabytes. Storage efficiency is affected by the addressing method: Larger disk clusters are used when MS-DOS addresses the entire optical disk, which means that smaller files waste a great deal of space. The manufacturers of optical disks have handled these issues in a variety of ways—some more successful than others, as I'll explain.

WORMs on the Bench

Instead of performing the normal BYTE drive benchmarks on these optical drives, I used a 100K File Copy, a Random Write/Read test, and (since a logical use for these large-capacity drives is for databases that are large but rarely changed) a Random and Sequential test on a database. The drives were tested with a Zenith Z-248 IBM PC AT-compatible computer running at 8 MHz with no wait states.

The File Copy benchmark involved copying a 100K-byte file from a RAM disk to the optical drive. This is the only benchmark that worked on all the drives. In two cases (the Franklin and N/Hance units), the original software supplied with the units would not allow the MS-DOS COPY command to work. (The drive manufacturers provided revised software, which did permit the COPY command to work.)

The Write/Read benchmark involved a program that first wrote a 64K-byte file sequentially and then read it back randomly. This benchmark did not run on the Franklin because, with the software available at the time of review, that drive did not allow programs to be run from the optical disk (or even run from the hard disk with output to the optical disk).

The database tests involved using dBASE II 2.43* to perform a sequential search and then a random search of a 117,760-byte database. The random search used an indexed database. I thought that this approached a more "real-world" use for such devices.

For comparison, I also ran each benchmark on a 20-megabyte MiniScribe hard disk drive installed in the Zenith Z-248.

IBM 3363

The IBM 3363 optical disk drive performed flawlessly during this review, although it is a little more complex to set up if you have a PC AT compatible: The controller card has a DIP switch that must be set according to the type of computer, and you have to reset it if you have an AT clone. The instructions are clear, however, and setting it up is straightforward.

The unit worked perfectly with MS-DOS; and DIR, COPY, CHKDSK, and every other MS-DOS command that I tried worked fine, even when installed in the non-IBM Zenith Z-248 computer. The unit appeared to act like a very large hard disk drive. While not all software will work with this or any optical drive (programs such as word processors that write temporary files will have trouble), I had no problems with dBASE II, or with reading (but not writing) files with WordStar 4.0.

Using software supplied with the unit, you can set up the disk as a single 200-megabyte MS-DOS disk, complete with subdirectories. In use, the 3363 is noticeable only by the soft whistling sound that the heads make when in motion.

The IBM controller card is a three quarter-length card that makes use of eight surface-mount integrated circuits. This does a great deal to reduce the bulk of the controller. The controller is connected to the drive by a thick cable with a 37-pin connector on each end. The drive itself features a pair of these connectors, so you can daisy chain drives for greater storage.

The optical disk media is unique to IBM and therefore cannot be interchanged with other brands. This is the only disk cartridge with a shutter designed to lock when it's out of the drive, to protect it from the prying fingers of hardware reviewers. Each single-sided disk holds 200 megabytes of data.

In all benchmarks except the 100K File Copy, the IBM drive was significantly slower than the other WORM drives. The File Write/Read test, for example, takes half again as long as the next slowest drive, and over 10 times as long as the fastest (see table 1).

Optotech 5984

The Optotech WORM drive has the same hardware components as the Franklin

continued

	IBM 3363	Optotech 5984	Franklin FLD 200
Type	WORM drive	WORM drive	WORM drive
Company	IBM Corp. Contact the dealer nearest you, or call (800) 447-4700	Optotech Inc. 740 Wooten Rd. Colorado Springs, CO 80915 (303) 570-7500 (800) 678-4225	Franklin Telecommunications 733 Lakefield Rd. Westlake Village, CA 91361 (805) 373-8688
Size	5½ by 9 by 16 inches	5⅛ by 8 by 16 inches	5½ by 10 by 16 inches
Board Size	10½ by 3⅞ by ⅜ inches	13⅛ by 4⅛ by 1⅜ inches	13⅛ by 4⅛ by 1⅜ inches
Features	Unit (uses single-sided 200-megabyte disks), controller card, cable, two floppy disks (device driver and diagnostics)	Unit (uses single- or double-sided 200-megabyte-per-side disks), controller card, cable, one single-side cartridge, three floppy disks (File Management and Access software, read/write device driver)	Unit (uses single- or double-sided 200-megabyte-per-side disks), controller card, one cartridge, three floppy disks (Archive Management System, File Management System, Developer's Toolkit)
Hardware Required	IBM PS/2, PC, XT, AT, or compatible with 128K bytes of RAM and one floppy disk drive	IBM PC, XT, AT, or compatible with 128K bytes of RAM and one floppy disk drive*	IBM PC, XT, AT, or compatible with 512K bytes of RAM and one floppy disk drive*
Software Required	PC-DOS 3.2 or higher	MS-DOS 3.0 or higher	MS-DOS 2.0 or higher
Documentation	One 204-page loose-leaf manual	One 468-page loose-leaf manual	One 214-page loose-leaf manual
Options	Internal version: $2700		Internal version: $3495
Price	$2950	$2950	$4600
Media Cost			
Single-sided	$65	$65	$95
Double-sided	N/A	$125	$175
	Inquiry 894.	**Inquiry 895.**	**Inquiry 896.**

*Because of controller size, this system may not fit all IBM PCs, XTs, or clones.

Table 1: *Benchmark results for the five optical disks tested. All times are in seconds.*

Drive	IBM 3363	Optotech 5984	Optotech 5984	Franklin FLD 200	N/Hance 525	Maximum Systems APX-3200	MiniScribe hard disk
Segment Size (in megabytes)	200	32	200	200	120	120	20
100K File Copy	3.2	4.6	6.0	6.0	3.6	17 6	1.1
File Write/Read	440 45	91 45	38.06	—	48 61	256 95	50.59
dBASE Random Read	23.9	20.5	15.7	—	12.2	24.4*	14.6
dBASE Sequential Read	25.0	21.0	12.3	—	8.7	49.0*	9 1

* Using dBASE III instead of dBASE II

Note: Neither the FLD 200 nor the APX-3000 would allow the File Write/Read and dBASE tests to be run from the optical drive, though the latter allowed the tests to be performed from the hard disk drive.

drive, although the two units function quite differently. The Optotech worked well with MS-DOS and is quite fast and easy to use.

However, there is a serious problem. The drive controller simply will not fit into all computers. I first tried to use the drive with a Tandy 1200 HD, which is an XT clone. The controller card is so thick—1⅜ inches—that it would not fit into a slot that had another card next to it. Since the Tandy, like many other PC clones, needs most of its expansion slots for normal use, this effectively prevents it and machines like it from using the Optotech controller.

The Optotech WORM drive controller is constructed of two full-length boards fastened together. Because the foil sides of the boards face each other, they are separated by a sheet of insulation and some standoff insulators. The two boards are connected by a ribbon cable that has a bulky connector on each end. The result-

N/Hance 525	Maximum Systems APX-3200
WORM drive	WORM drive
N/Hance Systems 908R Providence Highway Dedham, MA 02026 (617) 461-1970 (800) 289-9676	Maximum Storage Inc. 5025 Centennial Blvd. Colorado Springs, CO 80919 (303) 531-6888
5½ by 7 by 15½ inches	5½ by 7 by 15½ inches
5⅛ by 3⅞ by ½ inches	5⅛ by 3⅞ by ½ inches
Unit (uses single- or double-sided 120-megabyte-per-side disks), controller card, cable, three floppy disks (WORM-TOS, Text Scan, and electronic copy of manual)	Unit (uses single- or double-sided 120-megabyte-per-side disks), controller card, cable, floppy disk (MAXSYS-DOS)
IBM PC, XT, AT, or compatible with 256K bytes of RAM and one floppy disk drive	IBM PC, XT, AT, or compatible with 256K bytes of RAM and one floppy disk drive
MS-DOS 2.1 or higher	MS-DOS 3.0 or higher
One 146-page loose-leaf manual	Three spiral manuals, 130 pages total
Internal version: $2750 SCSI internal version: $2995 SCSI external version: $3250	Internal version: $2475
$2950	$2675
$95 $135	$125 $175
Inquiry 897.	**Inquiry 898.**

ing package prevents any board from occupying the slot to its left, and it intrudes badly to the right.

Once you have the Optotech controller in place, it is connected to the drive with a cable similar to that of the IBM unit but with only one 37-pin connector. The Optotech drive is also available for internal mounting.

The drive is easy to set up, and it gives you a wider variety of ways to format the optical disk than do the drives from other manufacturers. You can divide up the disk so that it appears to be three 32-megabyte disks, five 32-megabyte disks, or a single 200-megabyte disk.

You would use the three segments if you were planning to make frequent updates to the files on the WORM disk. Since you cannot erase files from a WORM drive, the Optotech software reserves extra space between the virtual disks (200 megabytes minus the three 32-megabyte segments—about half of each disk) to store the updates. It then flags the earlier versions of a file so that you don't normally see them.

You would use the five 32-megabyte segments if you planned to have a large number (up to 5 times 512) of small, relatively stable files on a disk. Because there is a 512-entry limit on the number of directory entries available (which is true of all DOS devices), you can store a greater number of files if you divide the disk into five parts. Since less room is left over with this five-segment division, you have much less room for updates, so you would want to avoid a large number of changes.

The 200-megabyte single volume is for the user with a smaller number of very large files on a disk. The device driver that gives access to this drive also adjusts the cluster size on the disk so that MS-DOS can address all 200 megabytes directly. Since the drive has only one directory to worry about when the drive is set up as a single large disk, access is faster, as the benchmark tests show.

The Optotech drive can accept single- or double-sided media, and each side provides up to 200 megabytes of storage. You can format the two sides differently; for example, one side of the disk can be formatted as several small virtual disks, and the other side as a single large disk.

Using a double-sided disk is less convenient than it might be. With all the units that use double-sided disks, you have to remove the disk and flip it over to have access to both sides. However, unlike the other drives, which release their disks at the press of a button, the Optotech drive makes you move the drive lever to the left and wait until a light stops flashing, indicating that the disk has slowed enough for it to be removed. You then move the lever to the other side, ejecting the disk. The wait for the light to stop flashing takes a minute or two, but it seems interminable.

The Optotech WORM drive was the fastest in the bunch. In its 200-megabyte format, it completed the File Write/Read test in a mere 38 seconds.

Franklin FLD 200

The only significant difference (in external configuration) between the Franklin FLD 200's hardware and that of the Optotech 5984 is the box: The FLD 200 is about 2 inches wider. Franklin also adds an additional 37-pin plug to the rear of the chassis so that additional drives can be daisy chained.

The real difference between the Franklin and the Optotech units is in the software that accompanies the drives. As originally released, the Franklin WORM drive could be used only as a single 200-megabyte drive for such limited purposes as file backup and text retrieval. It would not allow normal MS-DOS operations; I even had to use a special command to perform a COPY operation.

As I was finishing this review, Franklin provided me with a preliminary copy of its new software, which is designed to let the FLD 200 work with MS-DOS as if it were a hard disk drive. The software appears to be very similar (or identical) to the software from Optotech; it, too, lets you format the disk as either three or five 32-megabyte segments or as a single 200-megabyte disk. This was not a finished product, however, and I had some trouble installing it, so the results in table 1 (or the lack of them) are based on the original software. By the time you read this, the new software should be available, with results similar to those for the Optotech 5984 (as you would expect, since Optotech wrote the software).

Because the FLD 200 has the same

continued

controller card as the Optotech drive, it has the same problems in computers with limited internal space. As with the Optotech drive, changing disks or turning over a double-sided disk takes a long time.

Included with the FLD 200 is Franklin's Archive Management System, which lets you back up your hard disk and restore the files when you need them. You can generate command files so that the backup and restore processes are done automatically. Franklin also includes the File Management System, a number of utilities that let you copy and otherwise manipulate the files on the optical disk. According to the company, these programs cannot be used on the same files that are managed by the Archive Management System, because the latter keeps track of updates to the files and the former does not.

N/Hance 525

N/Hance Systems' 525 WORM drive is based on the ISI WC 525 drive and controller set that supports either single- or double-sided optical disks. These disks will hold about 120 megabytes of information per side. The drive can accept single- or double-sided disks, so you can store as much as 240 megabytes on each disk. (You still have to turn the disk over to use the other side.)

N/Hance's new operating system for its optical disk system, WORM-TOS (WORM Transparent Operating System), makes the optical drive act like a large hard disk drive. It supports MS-DOS operations. When you install it, WORM-TOS makes a patch to MS-DOS that is necessary if you plan to use segments larger than the 32-megabyte limit. Because I received this new software late in the review process, I was unable to spend as much time with it as with the other units, though I had no problems with it while performing the benchmark tests.

WORM-TOS makes the N/Hance drive faster than its lookalike from Maximum Systems; the Maximum Systems drive took between 2 to 5 times as long in every test. Table 1 shows the results of the benchmark tests as performed using the new software on a single-sided 120-megabyte disk.

Both of the ISI-manufactured drives in this review use a half-card controller that will probably fit into any PC or clone on the market. It had no problems with the tight spaces in the Tandy 1200 HD. The cable is also a little smaller, attaching with only a 25-pin connector.

This drive is easier to operate than the Optotech-manufactured drives. For example, you can remove the disk by simply pressing a button and ejecting it. In fact, the N/Hance software lets you eject disks using a keyboard command.

The company also includes a text-search-and-retrieval software package that lets you search for a specific word or group of words and then displays the text that contains those words. While I did not put this software through a rigorous test, I did download a portion of the BIX writers' conference and used the software to find items within that. It worked fine.

Maximum Systems APX-3200

Like the N/Hance 525, the APX-3200 is based on the ISI 525 WORM drive and half-card controller, so it uses single- or double-sided disks with 120 megabytes of storage on a side.

Installing the Maximum Systems drive was straightforward—easier than the complex set of instructions that comes with the drive would lead you to believe. It turns out that the factory default settings work in most installations.

Maximum Systems also includes MAXSYS-DOS, software that lets you use the drive with MS-DOS. This implementation of an MS-DOS device driver is not as successful as the ones on the IBM and Optotech drives. Most notably, you cannot run programs from the optical drive. According to the company, this is because some software writes temporary files to the disk. Whatever the reason, three other manufacturers succeeded in working around the problem, making their disks more convenient to use. Still, most commonly used MS-DOS commands worked properly.

Because the software doesn't let you run programs from the optical drive, I could not perform the File Write/Read test in exactly the same way as on the other drives. However, I was able to run the test from my hard disk drive, with the results written to and read from the optical disk. This is still, I think, a valid measure of performance.

Another problem with the APX-3200 is that dBASE II could not recognize the database files contained on the drive. The company says that other software, including dBASE III, can work with data from the optical drive, and I was able to perform the dBASE benchmarks using version 1.0 of dBASE III. The times given for this drive in the table are those for dBASE III, so they may not be comparable to the times for the other drives.

Winners in the WORM Race

Of the drives reviewed here, the IBM and the Optotech appear to the user to be most like ordinary drives, and you don't need to modify your operations to use them. Note that, of the two, only the IBM controller would fit into the tight spaces in my PC XT clone. On the other hand, the Optotech is significantly faster. With its WORM-TOS software, the N/Hance 525 is easy to use, fast, and reasonably priced. It, too, is worthy of consideration.

The Franklin FLD 200 and Maximum Systems APX-3000 seem overpriced for the performance they provide. The Franklin FLD 200 costs half again as much as the identical Optotech 5984. The Maximum Storage WORM drive has some operational problems (such as not being able to run programs from the drive), and its software seems to sacrifice speed for MS-DOS compatibility; it was quite a bit slower than the nearly identical N/Hance 525.

If I were buying an optical disk drive, I'd buy either the IBM 3363, the Optotech 5984, or the N/Hance 525. ■

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Turbo Pascal 4.0

Walter Banks

At last, you can break the 64K-byte barrier in Turbo Pascal. In fact, version 4.0 ($99.95) from Borland International has a multitude of new and revised features in addition to its modular design that lets you divide your program into separately compiled 64K-byte modules called units. The compiler runs on the IBM PC, XT, AT, PS/2, or compatibles under PC-DOS or MS-DOS 2.0 or higher with a minimum of 256K bytes of RAM for TPC.EXE, the command-line version (384K bytes of RAM for TURBO.EXE, the interactive menu-driven integrated environment), and one floppy disk drive.

Turbo Pascal 4.0 features the TURBO.TPL library of seven predefined units: system, printer, crt, dos, graph, turbo3, and graph3. It also features project-management tools; conditional compilations; Boolean evaluations; a single version of the compiler for both PC-DOS and MS-DOS; 4-, 6-, 8-, and 10-byte real data types; inline code; a substantially revised version of MicroCalc (Borland's spreadsheet); utilities; and 73 sample programs. Some of the examples are comprehensive programs demonstrating the use of various units. I was particularly impressed by the 56 small programs that demonstrated each function and procedure in the predefined graph unit.

Version 4.0 is not directly compatible with version 3.0, and some conversion is required. An Upgrade program comes with the new version, and the converting process is relatively simple. Version 4.0 also doesn't have the overlay facilities found in version 3.0.

I tested Turbo Pascal 4.0 on a 4.77-MHz IBM PC XT with 640K bytes of RAM, two floppy disk drives, and a 10-megabyte hard disk drive running PC-DOS 3.0.

Using Units

According to the Turbo Pascal 4.0 owner's manual, "A *unit* is a collection of

Its new modular design breaks the 64K-byte barrier of previous versions

constants, data types, variables, procedures, and functions." A unit is divided into two sections: The interface section contains "public" information that is visible to other programs using the unit; and the implementation section contains "private" information that is *not* visible to other programs but can be used by the interface section. Both sections consist of any or all of the five categories listed in the definition.

Units are not include files, but they are compiled and stored as machine code before being used. A compiled Turbo Pascal unit has the extension .TPU and is roughly analogous to a .OBJ file. TPUMOVER is a librarian utility with which you can add new units to the standard unit library, TURBO.TPL, or delete unused standard units from it.

The system unit contains Turbo Pascal 4.0's standard and built-in functions and procedures, as well as any "extras" that don't fall into another unit. Every program links to this unit; it, however, does not call any other units.

The printer unit sets up the variable Lst and connects it to a device driver so you can use write and writeln to send standard output to your printer. The printer unit calls the crt unit.

The crt unit is an IBM PC-specific I/O package providing keyboard and screen procedures and functions. This unit is the sole I/O interface for these devices and can be replaced by an application developer's own unit to support non-IBM PC-compatible displays and keyboards. Crt doesn't call any other units.

The dos unit defines those procedures and functions that equate to DOS calls, such as GetTime and SetTime. It also sets up Intr, which lets you use system interrupts, and MsDos, which lets you use MS-DOS calls. Dos doesn't call any other units.

The graph unit consists of more than 50 functions and procedures that run on the seven currently supported graphics adapters (i.e., CGA, MCGA, EGA, VGA, Hercules, AT&T, and 3270). It handles many different display resolutions by always setting the upper left corner to location (1,1) rather than trying to scale data from a virtual image to the real coordinates. Borland uses real coordinates in its graphics applications; you are responsible for any modifications to the scale of the display.

The graph unit is composed of several sections: the procedures used to report parameters about the current display, such as width, height, and aspect ratio; the graphics primitives to draw points, draw lines, and clear; the complex graphics routines to draw arcs and circles; and the composite routines that draw and fill pie charts and draw graphs. You can label images in one of four fonts, three of which are composed of the stroked-graphics characters typically used on plotters. Stroked fonts are easily scaled to fit the target space, more easily than dot-matrix fonts on applications that require changing resolution. Graph also uses the crt unit.

The turbo3 unit provides compatibility with version 3.0's Kbd, CBreak, MemAvail, MaxAvail, LongFileSize, LongFilePos, LongSeek, IOResult, and NormVideo, LowVideo, and HighVideo. The predefined Kbd device, used in version 3.0 to get unechoed characters from the keyboard, is not available under ver-

continued

Walter Banks is the owner of Byte Craft Limited, a contract research and development company specializing in development tools—many in Pascal—for small computer systems. He can be reached at 421 King St. N, Waterloo, Ontario N2J 4E4, Canada.

Turbo Pascal 4.0

Type
Pascal compiler and integrated development environment

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

Format
Three 5¼-inch floppy disks

Language
Not available

Hardware Required
IBM PC, XT, AT, PS/2, or compatible with a minimum of 256K bytes of RAM for the command-line interface (384K bytes of RAM for the interactive menu-driven integrated environment) and one floppy disk drive; an 80x87 coprocessor is supported, if present

Software Required
MS-/PC-DOS 2.0 or higher

Documentation
654-page softbound owner's manual, on-line documentation, documentation files for each of the supplied units

Price
$99.95

Inquiry 904.

sion 4.0. You can use Kbd from the turbo3 unit or ReadKey from the crt unit instead (ReadKey returns a character). The KeyPressed function tells you whether a key has been pressed on the keyboard. Version 3.0 mishandled this function (a write statement would clear it), but version 4.0 handles it correctly. Version 4.0 also returns a null rather than an esc as the lead-in character for the extended keys (i.e., function keys, cursor pad, and so on).

CBreak from version 3.0 is called CheckBreak in version 4.0. Version 3.0 gives memory available (MemAvail) and maximum memory available (MaxAvail) in quantities of 16-byte paragraphs; version 4.0 provides these amounts in byte counts. LongFileSize, LongFilePos, and LongSeek have changed from type real in version 3.0 to type longint in version 4.0. IOResult returns standard MS-DOS error codes in version 4.0, whereas it returned Turbo Pascal error codes in version 3.0. NormVideo, LowVideo, and HighVideo let you set normal, high, and low-intensity colors in version 4.0, whereas version 3.0 gives you standard defaults. Turbo3 uses the crt unit.

The graph3 unit provides support for the graphics routines in version 3.0. It also uses the crt unit.

Project-Management Tools

Turbo Pascal 4.0 includes the MAKE, TOUCH, and GREP utilities—project-management tools that are familiar to many C programmers. The MAKE utility is a standalone routine that calls all the code-generation routines (i.e., assemblers and compilers) required to produce current object files ready for the Turbo Pascal compiler to link into a single execution file. TOUCH is a utility that updates a file's current creation date and time so that the next MAKE forces a recompile. GREP is a powerful search program that quickly finds text strings in one or more files. For example, if you wanted a file containing all the procedure names in the Pascal files in a directory, you could enter GREP -i PROCEDURES *.pas >PROCS.TXT.

Borland also has project-management compiler options in version 4.0's integrated environment, which contains File, Edit, Run, Compile, and Option menus. For example, the Pick option on the File menu lets you select one of your eight most recently accessed programs and puts you back at your last cursor position in that program. The Compile menu includes Compile, Make, and Build options. The Compile option compiles the file currently in the editor. The Make option checks to see if any of the units involved in the program have changed since the last compile; if it finds any changes, the units affected are recompiled. In other words, the Make option ensures that your program is using all the latest versions. The Build option recompiles all the units involved in the program, regardless of whether any changes have occurred since the last compile.

Compiler options can be set within the source code as compiler directive commands, {$*directive*+} for On or {$*directive*−} for Off, chosen from the Compile menu in the integrated environment, or provided as command-line parameters: /$*X*+ for On or /$*X*− for Off in the command-line version.

Conditional Compiles

Turbo Pascal 4.0 can compile various sections of a program conditionally, a feature you can use for debugging or optionally including write statements. The following directives are available for conditional compilation: {$DEFINE *symbol*} defines a symbol for use by other compiler directives; {$UNDEF *symbol*} removes that definition. {$IFDEF *symbol*} compiles the code that follows it if the given symbol is defined, while {$IFNDEF *symbol*} does the same thing if the given symbol is not defined. {$IFOPT *directive*+} compiles the code that follows it if the given compiler directive is On, and {$IFOPT *directive*−} compiles it if the given compiler directive is Off. {$ELSE} acts the same as the ELSE in any IF...THEN...ELSE statement and can follow any of the {$IF*xxx*} directives, and {$ENDIF} indicates the end of an {$IF*xxx*} or {$ELSE} section.

These formats refer to compiler directive formats inserted into the source code, but the same results can be attained from command-line parameters or from menu choices from within the integrated environment.

You can also set up a symbol or compiler option to use as a Boolean expression to control the compilation of a code segment. You can evaluate a Boolean expression in two ways: Set the compiler to evaluate the expressions completely and then act on the results {$B+}, or evaluate the expressions only to the point where they succeed or fail {$B−}.

More New Features

Earlier releases of Turbo Pascal had separate versions for PC-DOS and MS-DOS. The PC-DOS version worked on IBM PCs and compatibles running PC-DOS, and the graphics library was PC-DOS-specific. The MS-DOS version worked on IBM PCs and other computers running MS-DOS. Turbo Pascal 4.0 has a single release for both operating systems. Code written for non-IBM computers, however, needs to avoid using IBM-specific units or IBM-specific options within a unit, as in graph, crt, and graph3.

Version 4.0 includes a 32-bit (4-byte) signed integer called longint among its data types. It also has byte (unsigned 1-byte), shortint (signed 1-byte), integer (signed 2-byte), and word (unsigned 2-byte) integers. Real data types come in 4-, 6-, 8-, and 10-byte varieties. The 6-byte reals are the same as reals in version 3.0. The remaining real types, single (4-byte), double (8-byte), extended (10-byte), and comp (8-byte), conform to the IEEE standard and work only on a computer equipped with an 80x87 coprocessor chip. Turbo Pascal 4.0 does not have an 80x87 emulation mode for the various IEEE format real data types.

You can include machine code in a program by using inline statements or directives. Inline statements are embedded code similar to that in version 3.0. Most existing inline code segments from version 3.0 need modification to reflect changes to the calling conventions between the two releases. Version 4.0 has also added an `inline` directive, or macro, that lets you code an `inline` procedure once and call it often by inserting the macro in several places.

In version 3.0, you have to create interrupt handlers in assembly language. In version 4.0, you can code them as Turbo Pascal procedures by declaring the procedure as type `interrupt`.

Converting from Turbo Pascal 3.0

Both of Borland's previous major releases of Turbo Pascal maintained almost total upward compatibility. This is not true for version 4.0. I found the program-conversion tools supplied with version 4.0 both useful and necessary. Two of the units (`graph3` and `turbo3`) in the unit library are specifically directed toward compatibility with version 3.0, and the Upgrade utility converts version 3.0 source code to version 4.0.

I found Upgrade easy to use. I tried executing it on my 3000-line Intel 8085 macro cross assembler to see what would happen. As it went through the mainline code, it followed the `include` files and updated them. Upgrade takes about as long as a version 3.0 compile on the same code, and it inserts corrections directly into your source code. Optionally, it can generate a report file with extensive hints on changes that you can make to the source code, and, in many cases, it refers to the reference manual pages by number.

In my haste to see some of my favorite code run, I immediately invoked the interactive version of Turbo Pascal 4.0 after running Upgrade. I had some warning messages, but I wanted to see what would happen. The compiler was about 400 lines into compiling the macro assembler before it stopped. After making a small fix and recompiling five different times, I successfully converted a piece of Turbo Pascal 3.0 application code to run under Turbo Pascal 4.0. This whole process took about 15 minutes—not bad for converting a 3000-line program to the point of running correctly.

The overlay facilities found in Turbo Pascal 3.0 are missing from version 4.0. If you used overlays in version 3.0 to get around the 64K-byte limit, you won't have a problem. In converting to units (via the /U, or unitize, option on the Upgrade program and the addition of {`.U` *unitname*} directives to your program), you can make your main program and each unit that it calls 64K bytes long. However, if you used overlays because your program exceeded the amount of memory available on your system, you will need to do some rewriting. Your main program and all the units it calls must fit into memory at the same time. Borland says that an intelligent overlay manager will be coming in a future release. I hope so, because version 3.0 has an effective overlay structure, and I'm sorry to see it go.

The default screen colors have also changed, from yellow on black to white on black. You can change them with the predefined `SetColor` and `SetBkColor` procedures. You can choose them from a palette of 16 colors, dependent only on the graphics driver you have installed and the graphics mode you have selected. In my experience, the transition time to move from version 3.0 to version 4.0 is short and relatively painless.

Benchmarks

I used the BYTE benchmarks to compare Turbo Pascal 3.0 with version 4.0. I wrote a short utility, `RUN.PAS`, to execute and time the benchmark tests. `RUN.PAS` measures the total execution time, including the time for the operating system to load the program from disk. It assumes that the program being run is in the current directory. I ran all the benchmark programs with version 3.02a, converted them via Upgrade to version 4.0, and then ran them again.

[Editor's note: *The benchmark files and* `RUN.PAS` *are available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents. To "find" source code in the Listings areas on BIX and BYTEnet, search by article title, author, or issue date. Some archived files may contain numerous listings for a single article. A description of the file also accompanies each entry.*]

Table 1 shows the execution times and code sizes for the two versions of Turbo Pascal. `CALC.PAS` tests multiplication and division for the 6-byte `reals`; version 4.0 is 39 percent faster than version 3.02a. `FLOAT.PAS` tests Turbo Pascal's library of transcendental functions, again using 6-byte `reals`. Version 4.0 shows speed improvement of almost 22 percent. `SIEVE.PAS` tests calculations and array manipulations; here, the improvement is about 12 percent. `TRANS.PAS` copies a file one character at a time, while `BTRANS.PAS` copies it in 128-byte blocks. `TRANS.PAS` shows only an insignificant (1 percent) improvement with version 4.0, while `BTRANS.PAS` boasts a healthy 26 percent improvement in speed.

`LINETEST.PAS` points out a major difference between the two versions. This benchmark tests the speed of Turbo Pascal's line-drawing routine. It shows an impressive speed increase of 253 percent. Some modification of the program was required for version 4.0, however. When first run, the screen was missing most of the required display lines. The problem lay in the fifth parameter of the `DRAW` procedure. Turbo Pascal 3.02a uses only the lower 2 bits of the color parameter, while version 4.0 uses all of them and requires you to ensure that the argument is in range. The timing for version 4.0 comes from the revised `LINETEST.PAS` program, which correctly displays the test. In all cases, the size of the execution code was significantly less for version 4.0.

I also ran the `HEAPTEST.PAS` benchmark, which initializes and disposes of Pascal heap pointers, each of which points to 9999 bytes (to avoid easy word boundaries). It executed under version 3.02a in 0.93 seconds, compared to 0.66 seconds under version 4.0. This represents an improvement in execution speed of about 41 percent.

All the benchmarks are small files; thus, compile times for the files were too short for me to measure. I decided to test a larger applications program to give measurable compile-time results. I chose the macro cross assembler. The only differences between the programs that I compiled under the two versions were the

continued

Table 1: *Turbo Pascal 4.0's execution times are significantly faster than version 3.02a's in most cases, and the decrease in version 4.0's execution code size is truly remarkable. (Times are in seconds; sizes are in bytes.)*

	Execute Time		Execute Size	
	3.02a	4.0	3.02a	4.0
CALC	32.68	23.51	11,635	4432
FLOAT	66.51	54.54	11,549	3536
SIEVE	16.37	14.61	11,713	2720
TRANS	80.08	79.21	11,544	2912
BTRANS	7.63	6.05	11,560	2928
LINETEST	21.09	5.98	11,533	8704
HEAPTEST	0.93	0.66	11,835	3104

Table 2: *An 8087 coprocessor is responsible for major improvements in execution time. There is little difference between the three lengths of IEEE* `real` *types, however. (Times are in seconds; sizes are in bytes.)*

	Execute Time		Execute Size	
	CALC	FLOAT	CALC	FLOAT
3.02a	7.08	2.97	10,282	10,194
4.0 (4 bytes)	2.31	2.09	4704	2608
4.0 (8 bytes)	2.64	2.09	4704	2608
4.0 (10 bytes)	2.69	2.09	4720	2608

changes inserted in the source code by Upgrade and the minimal changes I made so that the converted program would compile and run under 4.0.

The macro assembler source code under version 3.02a contained 94,140 bytes, and under version 4.0, 94,301 bytes. The `include` files required some disk activity for both versions. In this test, a version 4.0 compile by the interactive system was more than twice as fast as a version 3.02a compile (58 seconds versus 28 seconds). These measurements were made with a stopwatch and are accurate to within about a second. Just for fun, I ran these two compiles on an IBM PS/2 Model 50. The times dropped to 14 seconds for version 3.02a and 6 seconds for version 4.0.

The command-line version of Turbo Pascal 4.0 compiled the macro assembler in 38.1 seconds, which is slower than the interactive version, but the comparison is not direct. The command-line compile was run and measured by the `RUN.PAS` program, and the time given includes the time required to load the compiler as well as to compile the program. (This time was only 8.29 seconds on the Model 50.)

I also put together a 45,155-byte application file to provide a more realistic execution test. The execution time for this program was 75.75 seconds when it was compiled under version 3.02a, and 54.90 seconds under the interactive version of version 4.0. This is a substantial (38 percent) improvement in execution speed for a piece of real application code.

Table 2 compares the execution time and size of the `CALC.PAS` and `FLOAT.PAS` benchmarks with an 8087 coprocessor under Turbo Pascal 3.02a and Turbo Pascal 4.0 using 4-, 8-, and 10-byte `reals`. In Turbo Pascal 4.0, the `CALC.PAS` benchmark executes from 163 percent faster (for 10-byte `reals`) to 206 percent faster (for 4-byte `reals`) than it does in version 3.02a. `FLOAT.PAS` shows a 42 percent improvement for version 4.0 over version 3.02a, regardless of the length of the `reals` used. The change in the size of the code generated is substantial.

Something for Everyone

Turbo Pascal 4.0 has something for everyone. Third-party software developers can now supply maintainable units, and they are no longer limited to 64K bytes per program (as long as they adhere to the 64K-byte per unit limit). The Pascal user will like the improved interactive environment, and the novice will appreciate the extensive on-line documentation. I highly recommend Turbo Pascal 4.0 as an addition to any programmer's software repertoire. ■

MPW C for the Mac

Mike Wilson

The Macintosh Programmers' Workshop (MPW) is a powerful, well-integrated programming environment for the Apple Macintosh line of computers. MPW C is an implementation of the Green Hills Software C compiler for the 68000, 68010, and (with the release of version 2.0) the 68020 processors, running under MPW. Both MPW and MPW C version 2.0 are available from the Apple Programmers and Developers Association (APDA) for a reasonable price ($200 for MPW alone and $150 for MPW C). Together, they provide all the tools necessary to write complete applications for the Macintosh.

To test MPW C, I used a Mac II with 5 megabytes of memory. To run MPW, you must have a Mac Plus, SE, or II; at least a megabyte of RAM, either the 128K- or 256K-byte ROM; and a hard disk drive. The earliest versions of the system files that you can use with MPW are as follows: System 4.1, Finder 5.5, Laser Prep 4.0, Imagewriter 2.6, AppleTalk Imagewriter 3.1, and LaserWriter 4.0. The latest versions of these files are provided with the MPW package.

There are no additional system requirements for the use of MPW C. However, the MPW C reference manual section entitled "Compiler Limitations" states that the size of the largest function that MPW can compile is limited by available memory. Of course, MPW can generate applications that run on any Mac, if you take care to ensure compatibility. The MPW reference manual provides a short description of how to do this.

MPW is big. This is both a blessing and a curse. If you have a Mac XL (Lisa), Mac 128, Mac 512 or Mac 512e, or if your system has only floppy disk drives, you cannot use MPW C version 2.0. For a large number of Macintosh users, this means that MPW is not an option. In its defense, however, MPW is big for a reason: It is a *complete* development environment, with more than 40 support tools and scripts and a large volume of on-line documentation. It is, in my opinion, the first truly professional progamming system for the Macintosh.

The Environment

It would be incorrect to talk about MPW C without first mentioning the MPW programming environment—the "shell," as Unix users call it. The Macintosh's operating-system interface, the Finder, lacks the standard tools—such as editors and linkers—provided by most operating systems, so any language system on the Macintosh must provide these facilities itself. MPW collects all the needed language support into a completely new operating-system interface, designed specifically for software development.

When first executed, MPW appears to be simply a multiwindow text editor, with regular expression search and replace, bracket matching, a macro control language, multiple-named position marks ("bookmarks" to which you can attach names), and most of the other features programmers find useful. It is more than this, however. At any time, you can send a block of text, in any window, to the command processor by selecting the text and pressing the Enter key. The shell interprets and evaluates the selected text as a sequence of commands. The command processor inserts any produced output into the same window following the selected text. This "active text" model forms the basis for all interaction with MPW. When you launch MPW, it automatically opens a worksheet file containing commonly executed commands for easy selection and execution.

In the bottom left corner of the active window, to the left of the horizontal scroll bar, MPW writes the name of the command that the shell is currently executing. To show that a tool is running and not simply waiting for input, the cursor changes to a rotating ball.

The MPW command language is a complete programming language with I/O and flow-control statements. It is similar to the Unix C shell, but has a more consistent syntax. You can store MPW command-language scripts in files and execute those scripts by passing the name of the file to the command processor. If the file is in a currently open window, it executes directly with no disk activity.

You'll find most of the Unix development tools available in one form or another under MPW. This includes equivalents for `as`, `ld`, `make`, `spell`, `diff`, `grep`, and more. A file of aliases is also provided, which renames many MPW tools to their Unix equivalents.

MPW is not just "Unix with different names." One major difference is that, within the command language, MPW provides easy access to most of the user-interface facilities of the Macintosh Toolbox. You can access dialog boxes, notifiers, windows, menus, the standard file package, and the list manager with simple MPW commands. This lets you use menu-driven, dialog-based tools entirely with the shell.

MPW also improves on the generic "command line"-oriented shell syntax of Unix by providing a Macintosh-style dialog interface for all tools in the system. The dialog interface is stored as one of the tool's resources and is managed by a powerful on-line help facility called `Commando`. You can create new dialogs using `Rez`, the MPW resource compiler utility, or copy dialogs from some existing tool and modify them using `ResEdit` or a similar utility. You can then store these resources in the resource fork of user-written tools, allowing `Commando` to invoke them exactly like the built-in ones.

Generally speaking, MPW has more in common with interactive environments than with a traditional operating system.

Package Contents

MPW C comes on a single 800K-byte floppy disk containing the tool file (i.e., the code for the compiler), which is 233K bytes long, and three subdirectories containing source files. The total comes to 80 files and 773K bytes.

The MPW C reference manual is divided into four chapters. The first two chapters describe MPW C and how it can be used to write applications, new MPW tools, and desk accessories. The third chapter describes the "Standard C Library," a package of routines that implement Unix-style I/O, memory allocation, and utility functions. This chapter is organized as a series of one- or two-page entries, similar to those provided by the Unix `man` command. The documentation is sufficient so that you can use the Standard C Library functions without further references.

The fourth chapter, called "The Macintosh Interface Libraries," documents the Macintosh-specific header and library files. There is an incredible amount of information in this chapter, but it is too cryptic to be useful by itself. Don't expect to write Macintosh applications in MPW C without also having a copy of the book *Inside Macintosh* at hand.

There are more than 40 sections in chapter four, each one dealing with a different library. The contents of each section look like a sparsely annotated copy of a C header file. The chapter shows the functions (and their parameters) and the `structs` used, but nothing else. It is definitely a bare-bones reference section.

The C reference manual has several appendixes. The most important of these describes the register and calling conventions assumed by the MPW C and Pascal compilers. This lets you use C, assembly language, and Pascal routines in a single application.

The remaining appendixes give the contents of the distribution disk, the compiler options, information on using the 68881 math coprocessor, an index of the Macintosh libraries, and descriptions of the `Graf3D` and `Performance` libraries. The manual I had was a review draft that did not include the library index, but I am told that the production copy will.

Libraries and Other Software

The Macintosh interface libraries provided with MPW C include a complete set of routines for accessing the Toolbox, plus several other MPW-specific libraries. Included in this latter group are:

- `CursorCtl`, which handles the *rotating ball* cursor;
- `ErrMgr`, which supports MPW tool-error handling;
- `Strings`, for converting between Pascal and C strings; and
- `Performance`, which provides run-time performance analysis of C code routines.

MPW C version 2.0

Type
68000/68010/68020 C compiler for the Macintosh

Company
Apple Programmers and Developers Association
290 Southwest 43rd St.
Renton, WA 98055
(206) 251-6548

Format
One double-sided 3½-inch floppy disk drive

Hardware Required
Macintosh Plus, Macintosh SE, or Macintosh II; 1 megabyte of RAM, one hard disk drive

Software Required
Macintosh Programmers' Workshop (MPW is sold separately for $200)

Documentation
400-page *Macintosh Programmer's Workshop C Reference*

Price
$150

The toolbox interfaces follow, as closely as possible, the Pascal naming conventions used in *Inside Macintosh* for code written in C. The only significant differences occur in the way the Pascal variant records are translated to C unions. Because of the way references to unions are coded, you have to include an extra level of qualification. For example, the Pascal structure reference

```
aHParamBlockRec.ioBuffer
```

would have to be written as

```
aHParamBlockRec.ioParam.ioBuffer
```

in C. MPW C recognizes when you apply the wrong field identifier to a `struct`, making these easy to find and fix.

MPW Pascal represents string data by a structure with a 1-byte length field followed by up to 255 characters, called `Str255`. In C, however, strings are represented as an array of bytes, with the end of the string marked by a 0 byte. In an effort to make using the toolbox routines

continued

easier, MPW C has modified the C versions of the toolbox calls that take Pascal-format strings to accept C-format strings. Unfortunately, this is true only for strings that you pass directly as parameters. Strings that you have embedded in other data structures must be explicitly converted to `Str255` before you pass them to Toolbox routines. This is a potential source of confusion and error.

To test the compatibility of MPW C's Standard C Library (containing the Unix-style I/O calls), I tried compiling a text-based adventure game written for the Unix environment. The adventure compiled, linked, and ran, but it had problems outputting text to the screen (i.e., information that should have been printed on the screen was displayed only after I typed something). This was to be expected, since output to the current window is buffered under MPW, and no output appears until standard output has been flushed. Sprinkling a few `fflush(stdout)` lines through the file solved the problems, and the program worked fine. Since I had compiled it as an MPW tool, all the normal behavior of MPW was available so I could enter commands by typing them in and then pressing the Enter key. I could also select any command that I had already typed and press Enter to reexecute that command.

The MPW C distribution disk includes four sample programs (one each of the types of code modules that MPW supports): an MPW tool, a stand-alone application, and a desk accessory (DA). The fourth program is a test program for the C performance profiling utility.

The stand-alone application, `sample.c`, is a C language translation of the Pascal example program outlined in *Inside Macintosh* that shows how to encode the "event-driven" loop common to all Macintosh applications. It also shows how you can use compiler directives to force code allocation into specific segments. A companion file, `sample.r`, is a `Rez` resource compiler source file containing sample resource definitions for the menus, dialogs, strings, windows, and icons used by `sample.c`.

The example MPW tool, `count.c`, is a new utility that provides a number count of characters and lines in one or more files. This program shows how to call the `CursorCtl` library to display the spinning ball cursor while the tool is running. The associated `Rez` file, `count.r`, contains a resource definition for the `Commando` dialog.

You'll find the example DA source in the file `memory.c`. This DA shows the amount of available memory in the application and system heaps, and the free space on the boot volume.

Fortunately, a commented *makefile* to compile and link each of these programs is provided (you can think of a makefile as an intelligent batch file that you use to automate the steps of compiling and linking an application). You can hand-build makefiles for user-written programs, or generate them automatically using MPW's dialog-based makefile creation utility, `CreateMake`. This tool, which you can access from the default MPW menu bar, takes much of the tedium out of building makefiles.

Run That Baby

Invoking the C compiler from the MPW environment is as easy as typing. For example, using the Fibonacci benchmark code, you simply type

```
C fibonacci.c
```

If there are no errors, MPW C generates an object file named `fibonacci.c.o`. To create an executable MPW tool from this, you invoke the MPW linker tool with the object file you have created, by typing

```
Link -w -c 'MPS ' -t MPST
fibonacci.c.o
"{CLibraries}"CRuntime.o
"{CLibraries}"StdCLib.o
"{CLibraries}"CSANELib.o
"{CLibraries}"CInterface.o
"{Libraries}"ToolLibs.o
-o fibonacci
```

That's not quite right, because MPW commands are line-oriented; you must indicate that you want all lines joined together. To do this, you place the line-continuation character (i.e., option-D) at the end of every line but the last. The option-D character displays as a lowercase delta. (Although this shows how an MPW tool is created, building stand-alone applications and desk accessories is almost exactly the same process.)

Several options provide control over the behavior of the compiler. Some options, like `-mc68020` and `-mc68881`, cause the compiler to generate code that is optimized for the Mac II and will not run on any other Macintosh.

Another nice feature of the C compiler is the way that it reports syntax errors. The output produced by the compiler displays error messages on two lines. The first line starts with a sharp (#) character followed by a text description of the error. The second line looks something like `File fibonacci.c; Line 14`. As well as being a description of where the error occurred, you can pass this line to the MPW shell as a command to open the file `fibonacci.c` and go to line 14. To execute the command, click anywhere on the line and then press the Enter key. This makes it easy to go exactly to the place where the error occurred.

Like most C compilers, MPW C has a tendency to print many extraneous error messages once one real syntax error has occurred. You can interrupt the compiler (and most other MPW tools) at any time by pressing the command-period key sequence. This immediately halts the compiler and returns you to the shell.

Benchmarks

I ran the standard byte benchmarks under MPW C in three different configurations:

- No options.
- The `-mc68020` option enabled to allow the extended 68020 instructions and addressing modes to be used.
- The `-mc68020`, `-mc68881`, and `-elems881` options enabled to allow in-line floating-point coprocessor instructions to be generated as well. (To use the 68881 options, the code must link with a different set of math libraries because of the differences in number format between Sane and the 68881.)

The results for each combination of compiler options are shown in table 1. The most interesting conclusion you can draw from this table is that the MPW C compiler is fast at compiling small programs. This is particularly important when writing small tools like filters or program fragment generators which are used only once or twice. Unfortunately, I found that the compiler does not do as well when compiling large programs.

The benchmarks reveal two other facts. First, the `-mc68020` option by itself provides improvement only in the Quicksort benchmark, which consists predominantly of long array referencing. If you allow 68020 instructions, you can expect improvements in 2-, 4-, and 8-byte table references, as well as `switch` statement dispatching, bit-field operations, and long multiply and divide operations. To some extent, the benchmarks show this. Second, the in-line coprocessor instructions are much faster than Sane for all floating-point calculations.

Problems

One of the more serious problems I encountered while working with MPW C version 2.0 is that it cannot compile large functions. The reference manual states that available memory constrains the maximum size of a single function, so I expected limitations to exist.

To test this problem, I tried compiling an old, monolithic C program that I wrote for the DSI-780. [Editor's note: *For a re-*

continued

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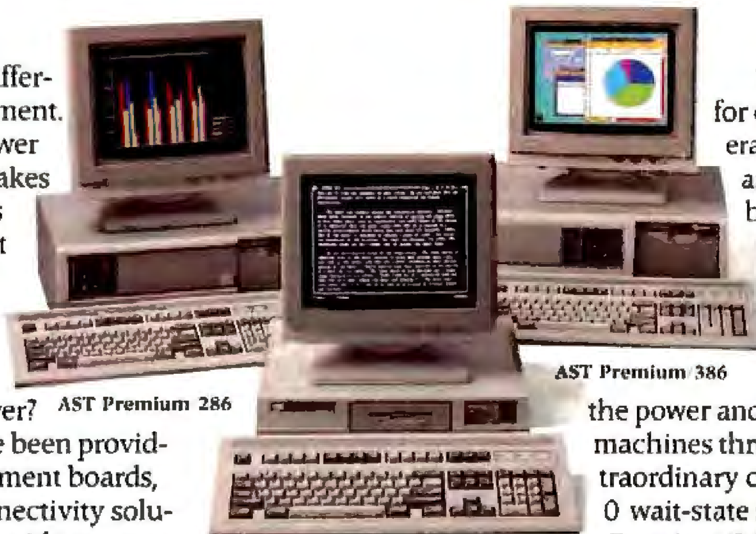

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view of the DSI-780, see "The Definicon DSI-780" by Dave Thomas in the October 1987 BYTE.] By "monolithic," I mean the program was about 2000 lines long, written *as a single function*. The body of the function was a `while` loop wrapped around two 256-element `switch` statements with several embedded `goto` statements. If MPW C could compile this, it could compile anything!

On the DSI-780, which uses the Silicon Valley Software 68020 C compiler, compiling this megafunction takes less than a minute in 2 megabytes of memory. On the Mac, using MPW C, I waited for over 15 minutes to discover that 5 megabytes was not enough memory.

By playing around with the code, I found it was not the program's size that was important; it was the branch complexity. I eventually cut enough of the code out and got to a point where adding a single `goto` from anywhere to anywhere caused the compiler to run out of memory, but adding 100 lines of straight-line code worked. At this point however, MPW C was still taking close to 15 minutes to compile the program.

Other problems with MPW C seem to be a result of running in the Macintosh environment. Because of time constraints and code complexity, I was not able to research these problems carefully, but I noticed that using both the Unix-style buffered-file I/O (e.g., `fopen` and `fread`) and Toolbox file-system calls in a single application caused occasional crashes, even though I never applied the two sets of routines to the same files. I also noticed that calls to `malloc` for more than the available amount of memory occasionally caused bomb boxes to appear. Presumably, allocating too much memory causes an application to perform heap compaction. If the application is using a pointer to an unlocked block of memory—goodbye, Charlie.

Simply because MPW C is compiling for the Macintosh, there are two more problems which it must have. Notice that these are not the faults of this compiler; all Macintosh applications have these limitations. The first is that the code generated must be completely position-independent. This limits the size of the largest code segment to 32K bytes, because of the limit on the size of the offset for relative branch instructions. Breaking up

continued

Table 1: *Benchmark results for various compiler options: (a) No options, (b) with the -mc68020 flag set, and (c) with the -mc68020, -mc68881, and -elems881 flags set. These are the standard BYTE C benchmarks (see "MPW Compiler Lets Mac II's 68020 Shine" in the November 1987 BYTE). All times are in seconds, except the Dhrystone, which is in iterations per second.*

	(a)	(b)	(c)
Dhrystone	2500	2631	2941
Fibonacci	52.4	52.4	52.4
Float	79.1	79.1	79.1
Quicksort	9.1	9.1	12.5
Savage	326	326	3.7
Sieve	6.3	6.3	6.3

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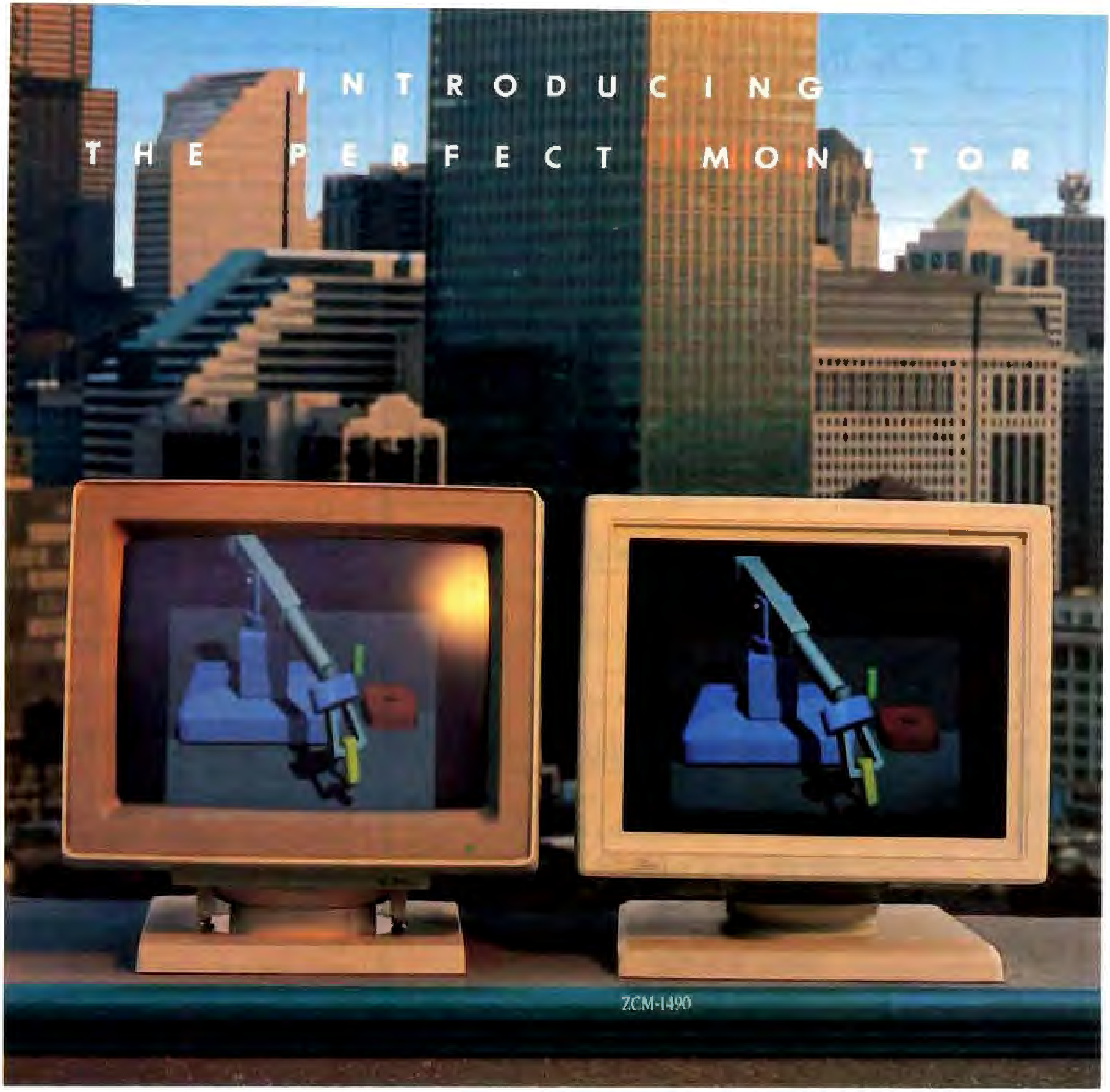

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large programs into 32K-byte segments can cause considerable speed penalties if the program has a highly connected call graph. The second limitation imposed by the Macintosh environment is that a single application can use no more than 32K bytes of global variables. This means that, when translating existing programs for the Macintosh, you must be careful with programs that use large global arrays (you'll probably have to revert to `malloc` to create the array space).

What Is Missing

No matter how good a system is, every avid user forms a list of features that he or she thinks it absolutely must have. For MPW C, my wish list is as follows:

- An object-oriented extension to C such as Object Pascal for MPW Pascal and the Object Assembler macros for MPW assembler.
- A source-level debugger. A multiwindow, multilanguage, symbolic source-level debugger would help remove my remaining doubts about MPW.
- A facility for writing in-line assembly language code, even though I know the authors of MPW C would cringe at the idea. First, putting in-line assembly language code in the middle of a function makes it impossible to do global optimization around it. And even if they do allow in-line assembly language, they don't currently generate an intermediate assembler file, so they would have to write an assembler specifically for this. Even so, there is always that one time when just one assembly language statement would make all the difference.
- More control-key functions for the editor. The MPW editor has command-key equivalents, but not enough. Machines like the Symbolics Lisp machine seem to get along well with both a mouse and EMACS-style control keys, so I don't know why the Macintosh can't too.
- Cross-referencing and formatting tools like those provided for MPW Pascal.

In general, I have been happy with both MPW and MPW C. On a Mac II especially, the combination provides a fast and useful development environment. For small programs, probably any of the Mac C compilers would be useful, but for large applications and commercial systems, I think this is the way to go. ■

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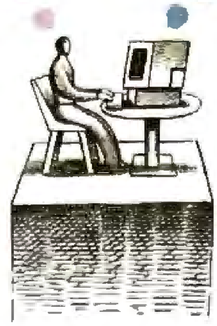

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dBASE Mac vs. McMax

Namir Clement Shammas

Two software companies provide competing database managers for the Macintosh

Ashton-Tate, makers of dBASE III for the IBM PC and compatibles, recently introduced its Macintosh database package, dBASE Mac. This database package is *not* a port of dBASE III Plus to the Macintosh. Instead, it's a new database manager application tailored for the Macintosh environment. It costs $495.

Nantucket Corp., makers of dBASE III Plus compilers for PCs, has launched a single-user dBASE III Plus interpreter for the Macintosh, dubbed McMax, for $295. Surprisingly, McMax resembles the PC version of dBASE III Plus more than dBASE Mac does, and McMax is fully compatible with dBASE III Plus files while dBASE Mac is not.

The designers of dBASE Mac version 1.0 have implemented a user-friendly Macintosh interface. In addition to the main pull-down menus, dBASE Mac provides a few MacPaint-like palettes that supply, with one mouse click, many of the same menu options. Menus and dialog boxes offer you many features. By contrast, McMax's summer 87 version employs the Macintosh interface with more moderation as a PC-ported product. A draggable window of fixed size presents you with a "." prompt where you can type in various commands. Pull-down menus let you modify various settings (normally controlled by the `SET` commands), reenter frequently used commands, and use the assist mode.

Both packages provide you with on-line help: Just select the `help` option from the desk-accessory menu. The styles of the two help systems differ markedly. dBASE Mac provides on-line help by topic: Two menu levels direct you to a window containing step-by-step information on the use of a command. McMax's on-line help presents an alphabetized list of commands and functions that you can scroll through and double-click on for help. A brief summary of the command's or function's purpose and syntax is given. Both systems provide adequate help, but the depth of dBASE Mac's help information is more suitable for the novice, whereas McMax's terseness better serves those familiar with dBASE III Plus.

Types of Information

The field and data types used to create files are more elaborate in dBASE Mac than in McMax. The Ashton-Tate package greatly departs from the types of fields found in dBASE III Plus. The data types supported by dBASE Mac include text, numbers, dates, times, logical values, enumerated choices, and graphics (created by MacPaint).

By contrast, McMax implements the same fields as dBASE III Plus does, while increasing the ranges and capacity of several of these fields. The data types supported are text, numeric, logical, date, and memo. Table 1 compares some of the capabilities of the two Macintosh applications and the PC-based version of dBASE III Plus.

The task of creating a new file structure in dBASE Mac demonstrates the clever and extensive use of pull-down menus. A dialog box appears on the screen and includes several input and check boxes. The input boxes enable you to define items such as the field name, field type, data type, singularity of field content, and so on. Using check boxes, you can indicate the status of a field. For example, you can specify whether or not a field is a secondary index, or if it requires a value, or (for text fields) if its contents follow a pattern.

The designers of dBASE Mac have backed up the use of field types with a high level of sophistication. For example, when you select a field to contain text data, you are given the option to specify a list of character patterns that define a valid input. At the end of a field definition, you can select the `Clear` option to reenter the information, `Save` to define another field, or `Done` to end the file structure definition.

Once you define a file structure, dBASE Mac prompts you for the number of records in the data file using the structure you created. The structure window displays a corresponding box with the fields stacked up. Using the mouse, you can pick any field for deletion or modification. You can reorganize the file to increase its size and remove fields and dBASE records marked for deletion.

Defining a file structure using McMax basically follows the footsteps of dBASE III Plus. The screen displays a form with the field name, data type, length, and number of decimal places (for numeric fields only). Field names are limited to 10 characters, and you can move the cursor from one field attribute to another by pressing the Tab key. The `MODIFY STRUCTURE` command is used to redefine the file structure of the active database. Altering the name and length of fields requires invoking the `MODIFY` command twice: first to alter the field name, and then to change the field length. Indexing on fields is performed separately from the structure definition, using the `INDEX ON` command to establish the file of indexes.

Viewing the file structure in dBASE Mac requires that you view the specification of single fields, one at a time. In contrast, McMax lets you use the `DISPLAY STRUCTURE` command to view the simple file structure definition.

dBASE Mac reads data files created by other database products such as dBASE II/III/III Plus, Excel, Microsoft File,

continued

Namir Clement Shammas is a freelance writer and columnist for several computer magazines. He can be reached at 4814 Mill Park Court, Glen Allen, VA 23060, or on BIX as "nshammas."

dBASE Mac version 1.0	McMax (summer 87 version)
Type Database package	**Type** Database manager package
Company Ashton-Tate 20101 Hamilton Ave. Torrance, CA 90502-1319 (213) 329-8000	**Company** Nantucket Corp 12555 West Jefferson Blvd., Suite 300 Los Angeles, CA 90066 (213) 390-7923
Format Four 3½-inch double-sided double-density disks	**Format** Two 3½-inch double-sided double-density disks
Language N/A	**Language** C and assembly language
Hardware Required Macintosh Plus, SE, or II with a hard disk; supports Imagewriter, Imagewriter 15, Imagewriter II, LaserWriter, and LaserWriter Plus printers; 68881 coprocessor, color monitors	**Hardware Required** Macintosh 512KE, Plus, or SE with a hard disk drive (recommended), or Mac II; supports Imagewriter and LaserWriter printers
Software Required System 4.1/Finder 5.5 or higher	**Software Required** System 4.1/Finder 5.5 or higher
Documentation 15-page *Getting Started with dBASE Mac* 148-page *Learning dBASE Mac* 336-page *Using dBASE Mac* 46-page *Exchanging Files with dBASE Mac*	**Documentation** 267-page *User's Guide* 320-page *Reference Manual*
Price $495	**Price** $295
Inquiry 900.	**Inquiry 901.**

Table 1: *A comparison of features among dBASE Mac, McMax, and the PC-based dBASE III Plus.*

	dBASE Mac	McMax	dBASE III Plus
Maximum files open	30	32	15
Maximum records per file	Unlimited	16 million	1 billion
Maximum record size	32,000	32,000	4000
Maximum number of fields per record	32,000	2000	128
Maximum size of single text field	255	255	254
Number of digits precision	19	18	16
Maximum size of a memo field	N/A	32,000	5000
Types of data	Text Number Date Logical Choices Time Graphic	Character Numeric Date Logical Memo	Character Numeric Date Logical Memo

Jazz, Multiplan, Helix, Double Helix, PFS:File, and Reflex.

dBASE Mac regards imported records as belonging to a foreign data structure. Such files have restrictions and limitations imposed on them. For example, when I imported a dBASE III Plus type file (created by McMax), the index field lost its status as an index. Moreover, I could not redefine any field as an index, since dBASE Mac does not support the indexing of foreign file structures. dBASE Mac also supports exporting data into foreign file structures. This allows a two-way data transfer between dBASE Mac and other database packages.

McMax can read data in a dBASE III Plus file format but does not offer the import/export foreign file-structure features. Since the dBASE III Plus file format is supported by many other database managers, the lack of this capability should not be a problem.

Getting to the Data

Accessing data in a dBASE Mac file requires that you define a *view* form. Views may be customized, columnar, or form layouts, and they are used to define reports. The steps involved in selecting the fields for viewing (which may come from various related files) are more sophisticated than the steps required in dBASE III Plus, but they give you full control of creating professional-looking forms. This includes selecting the character fonts (e.g., bold, italic, and underlined) and the letter sizes, as well as incorporating artwork.

To define a view, you select the fields appearing in the form and design their layout (either for customized or form layouts). You can optionally specify a data-filtering condition (using a logical expression) or a sorting order. The form and customized views can enter or search for data. By contrast, a columnar view only displays data.

Using view forms takes two routes: The first route displays the latest version of the view, without any updates; the second route makes dBASE Mac update the view to reflect any new data, new data filtering, or a new sorting order. I found that dBASE Mac displays columnar forms rather slowly. This problem also occurs when scrolling vertically.

dBASE Mac lets you access fields in various files using data paths. A data path resembles the reference to fields in Pascal or C record structures. Another new feature implemented by dBASE Mac supports the mechanism of binding the data file and views into a project. Thus, when you select a project icon, you load dBASE Mac, the data file, and all related views. This kind of binding adds the integration missing from dBASE III Plus.

McMax supports the data I/O methods familiar to dBASE III Plus programmers. The APPEND command lets you enter data instantly once you have defined a file structure or invoked a predefined one. APPEND resorts to a simple data-entry form automatically created by McMax. User-written McMax applications programs provide custom entry forms and data verification. McMax also supports commands that let you list your data on the screen, with the option of applying view filters. These commands can be incorporated into program files to develop customized view forms.

dBASE Mac lets you establish links between different files: Just use the mouse to point to and drag fields from one file to another. McMax supports relations among different databases using the dBASE III Plus commands and syntax.

Table 2: *The benchmark results show that McMax completed the BYTE Sort and Search tests an average of about 2.5 times faster than dBASE Mac. All times are in seconds.*

Test		dBASE Mac	McMax
Sort	Indexed	29	11
	Unindexed	30	11
Search	Last Key Field	3.6	1.3
	Nonexisting Field	3 2	1 8

Notes

(1) The indexed Sort test measures the time to sort records arranged in ascending order to descending order on an indexed field in the file. The unindexed Sort test measures the time to perform the same sort on an unindexed secondary field in the file.

(2) The Search Last Key Field test measures the time to find the last key field record in the file. The Nonexisting Field test measures the time to locate a nonexisting field that is supposed to be after the last field. A 254-record database file, sorted in ascending order, was used for both tests.

Customizing

The programmability of dBASE Mac is based on attaching procedures to various fields, files, views, or fields of views. There are five kinds of procedures: preprocessor, postprocessor, new-record, delete-record, and write-record. Routines are classified according to their activation times. Preprocessor procedures are attached to a view or to one of the view's fields. They automatically execute whenever a view is visible. Postprocessor procedures can attach to a view or to fields in a file. They execute after a data field is entered or after a view is closed. New-record procedures provide you with additional flexibility and are automatically executed when you request the creation of a new record. When using this kind of procedure, you must include a NEW(SELF) command to create the new record. Similarly, the delete-record and write-record procedures are activated when their corresponding tasks are invoked from the menu. dBASE Mac lets you attach multiple procedures to a field, a file, or a view and are executed in sequence. Nested procedures are also supported.

Programming with McMax includes the use of one or more program files. A main program file is explicitly invoked to execute its own instructions or to invoke other program files. McMax supports program and format files. Format files include special programming instructions that let you replace the standard-screen input form with a customized input form. Thus, like dBASE III Plus, McMax supports modular program development in a more traditional style.

Both packages support simple variables. McMax, like dBASE III Plus, lets you store all or some memory variables in a separate file and recall them later. dBASE Mac implements one- and two-dimensional arrays.

Both programming languages support assignment statements, with a wide variety of operators and a vast number of predefined functions available. The IF...THEN...ELSE and CASE decision-making constructs are also available in both packages. dBASE Mac offers a few more loop constructs than McMax: The FOR, WHILE, REPEAT...UNTIL, and open LOOP constructs are implemented in dBASE Mac, while McMax provides only the first two loop constructs. dBASE Mac offers the WHEN LEAVE clause to exit an open LOOP, while McMax uses the EXIT keyword to leave a DO...WHILE loop. Since McMax supports programming in a more traditional structure, you can also declare procedures with parameters in program files.

dBASE Mac supports an additional suite of commands new to the dBASE III Plus programmer, including activating other projects as well as invoking and controlling views. dBASE Mac supports commands to perform file I/O, message prompting, and debugging—all of which have equivalent commands in McMax.

Comparing Performance

Testing dBASE Mac and McMax proved to be quite a challenge. The first step was to create a 1000-record database. I wrote a program in McMax that automatically created the 512-byte records needed to build the database, with the records arranged in ascending order. The structure contained a 156-byte key field, two 100-byte filler fields, and a 156-byte secondary-key field. After performing the Sort and Search tests for McMax, I ported the database to dBASE Mac, which treated the imported file as a foreign one. This meant that my original key field was no longer indexed, since dBASE Mac was using the record number as the key field. Moreover, I could not make a new index for any field of the database. Consequently, I resorted to programming dBASE Mac to create the required database. I created a view to carry out the job at hand. Unfortunately, the process was so slow (an estimated 16 hours) that I had to stop the program after several hours when it had created only 254 records. I edited the McMax program to make a database of the same size. The tests were carried out using a Macintosh Plus with a 20-megabyte hard disk drive (see table 2 for the timing tests). The timing tests reveal that McMax outperformed dBASE Mac by 2 to 3 times.

dBASE Mac and McMax are two very interesting databases, each having a different appeal. Ashton-Tate has taken the courageous step of an innovator and has come out with a new database that caters to the Macintosh environment. However, dBASE Mac is slower in screen redrawing and other file operations.

For a dBASE applications developer, learning a whole new set of commands to use dBASE Mac is the price you'll pay for working with this powerful database. Veteran dBASE III Plus programmers (who have spent hours learning dBASE) may not like the thought of going back to the dBASE Mac training boot camp.

Nantucket Corp., on the other hand, is a good imitator that implements a fast version of dBASE III Plus for the Macintosh. It has an immediate appeal to dBASE users and especially to dBASE consultants who want to expand their customer base to include Macintosh owners. The speed, high level of code portability, and reduced retraining effort are the major strengths of McMax. ■

MathCAD 2.0

George A. Stewart

Despite the obvious appeal of a combined problem-oriented number cruncher and documentation tool for mathematics, MathSoft's MathCAD version 2.0 ($349) for MS-DOS computers has no direct competition. Mathematically oriented products have tended to go one way or the other—into number crunching or into representing math formulas in traditional notation. UTS' TK Solver Plus, Borland's Eureka, and Dalin's Scientific Wheel fall into the former category, whereas TSSI's Exact and a number of word processors fall into the latter. [Editor's note: *For a review of TK Solver Plus and Eureka, see the October 1987 BYTE.*]

MathCAD requires MS-DOS or PC-DOS 2.0 or higher, 512K bytes of RAM, and a CGA, an EGA, or a Hercules monochrome adapter. A floating-point coprocessor unit (FPU) is recommended.

When you first look at a MathCAD screen, you get the impression that it's a bit-mapped image à la Macintosh, with custom fonts for the special mathematical symbols and structures. As you scroll through a document, you realize it can't be—the scrolling is too fast for bit-mapped information. MathCAD's neat trick is to use the extended IBM character set for everything on the screen, except for graphs and a few characters not included in the character set. All the characters are placed accurately, giving the formulas an impressive appearance.

The drawback to this approach is that MathCAD offers only one character size, where normal math notation uses at least two: one for main-level variables and one for subscripts and superscripts. Also, MathCAD has to use roman text characters throughout the display, even though it is customary math notation to use italics for variables.

A Computer-aided Scratchpad

MathCAD is not as structured as TK Solver Plus with its sheets and subsheets. Instead, it lets you work almost exactly as you would on paper, using a two-dimensional document whose size is limited only by the amount of memory available (and by the memory required to perform the calculations specified in your document). The only structure imposed by MathCAD is that of *regions*: rectangular areas of variable size containing text, an equation, or a plot. The only restriction on regions is that they cannot overlap; otherwise you can arrange them horizontally and vertically as desired.

Every text block, equation, and graph occupies its own distinct region. Regions can be cut, copied, and pasted into new areas with single keystrokes. However, you cannot copy more than one region at a time—even though this would be a useful capability, since quite often you may want to move a related set of equations. MathCAD does allow cut-and-paste editing of expressions within a region. An additional word-processing-like feature that speeds up equation-editing is MathCAD's search and replace command.

Ordinary text (e.g., notes, labels, and explanations) goes into text regions. A certain number of traditional word-processing format controls apply to MathCAD's text regions, such as selectable margins and automatic word wrap.

A special kind of text region, called a band, is for longer passages of text. Bands stretch across the width of the document and have additional formatting capabilities, such as centering and underlining.

Anything you type outside of a text region becomes an equation or a plot region. While you are typing in one of these regions, most of the punctuation keys and Alt-key combinations have special meanings to speed the entry of mathematical notation. For instance, typing b:a^2 causes b := a² to appear on the screen. To leave an equation or a plot region, you press Return or move the cursor away from it.

When set to automatic mode, MathCAD recalculates each equation as soon as you finish editing it. It also automatically reevaluates equations that are dependent on the results from the edited equation. In manual mode, MathCAD recalculates only when you press the calculate key (F9). It does not recalculate everything in the document each time you make a change. This is an advantage over Eureka and TK Solver Plus, which must reevaluate the entire model after any change is made.

To determine the relationships between equations, MathCAD uses the same approach used in written expositions: left to right and top to bottom. For instance, a variable must be defined in an equation physically preceding any equation or plot that uses that variable. The exception is the global definition, indicated by the ≡ symbol. Global definitions can appear anywhere.

In summary, MathCAD's notion of cursor-activated regions makes it easy to build a complicated presentation that looks exactly the way you want it to. The program has a command line for special operations, such as filing a document, selecting a printer, setting global formats, entering DOS commands, and setting the MathCAD start-up configuration. In addition to the command line, a set of pull-down menus lets you perform the same tasks.

Plotting and Printing

Plotting is both versatile and intuitive in MathCAD—more so than in Eureka or TK Solver Plus. You type @ to open up a plot region, then move to several preset fields in the plot to fill in the x- and y-axis expressions and x- and y-axis ranges. You change the size of the plot, the line type, and other characteristics by entering a format command on the command line. Available line types include dots, lines connecting the dots, lines with points shown as diamonds, and staircase lines composed of horizontal and vertical increments. It is possible to plot multiple functions on the same graph. MathCAD's range variables make it easy to generate a set of discrete points for the graph. You can set the graph limits manually or let MathCAD assign values based on the calculated point range.

MathCAD can print an entire document or any contiguous group of regions that you specify. The program uses custom printer drivers that take advantage of the printer's built-in character matrix and compatibility with the IBM extended character set. For printers lacking the extended character set, MathCAD uses a bit-mapped font to generate the characters. Plots and boxes are done through graphics printing, as they are on the MathCAD screen. Printer drivers are supplied for IBM graphics printers (80- and 132-column), Epson graphics printers (80- and 132-column), and the NEC P5, Okidata 92/93, Toshiba P351, HP ThinkJet, HP LaserJet, and plotters that use HP Graphics Language (HPGL).

In the case of dot-matrix printers, MathCAD divides the document into pages. For HPGL plotters, it compresses the entire area to be printed onto a single page.

Technical Capabilities

MathCAD stores floating-point numbers in double precision according to the IEEE 754 specification. It recognizes that real numbers are embedded in the

continued

MathCAD version 2.0

Type
Mathematical problem solver and documentation tool

Company
MathSoft Inc
One Kendall Square
Cambridge, MA 02139
(800) 628-4223

Format
Two 5¼-inch 360K-byte floppy disks or one 3½-inch 1.2-megabyte floppy disk

Language
Microsoft C 4.0 and assembly language

Hardware Required
IBM PC, XT, AT, PS/2, or compatible with 512K bytes of RAM and a CGA, an EGA, or a Hercules monochrome adapter; an 8087 or 80x87 coprocessor is recommended.

Software Required
MS-DOS or PC-DOS version 2.0 or higher

Documentation
290-page wire-bound tutorial and reference manual, 12-page quick reference manual

Price
$349, $50 for owners of earlier versions of MathCAD

Inquiry 902.

complex plane, and it automatically displays a result in complex number format ($a + bi$) when the ratio of b to a reaches a certain user-definable tolerance setting. MathCAD also accepts hexadecimal and octal numbers, storing them as 32-bit integers.

MathCAD's built-in constants include $\pi = 3.14159$, $e = 2.71828$, $\infty = 10^{307}$, % = .01, TOL = .001 (the default tolerance for numerical approximations), and ORIGIN = 0 (the default starting index for arrays). You can change these by reassigning new values within the document.

In addition to arithmetic operators, MathCAD includes built-in operators and notation for factorials, complex conjugates, square roots, absolute values, sums and products of subscripted expressions, integrals and double integrals, and derivatives. Array operations include a vec keyword to force element-wise evaluation of matrix operations.

Built-in functions include trigonometrics and their inverses; `angle (x,y)` for the angle of a ray from the origin to a point; hyperbolic trigonometrics and their inverses, exponentials, and natural and common logs; and `Re(z)`, `Im(z)`, and `arg(z)` to return real part, imaginary part, and angle of complex numbers. More advanced features include Bessel functions, linear and cubic spline interpolation functions, and real and complex fast Fourier transforms (FFTs) and inverses. For statistical work, MathCAD has nine built-in functions (correlation, slope and intercept of the regression line, mean, standard deviation, variance, gamma function, error function, and cumulative normal distribution function).

For vectors, there are `length`, `last`, `max`, and `min` functions. For matrices, there are functions to calculate the number of rows and columns, sum of diagonal elements, identity matrix, and several more esoteric functions. Solving functions include `root`, which finds the value of a variable that makes an expression zero-valued; `Find`, which solves one or more variables in a solve block; and `Minerr`, which finds values for one or more variables that minimize the error in constraints within a solve block. Miscellaneous mathematical functions include `floor()`, `ceil()`, `rnd()`, `mod(x,y)`, and `Φ(x)` (returns 1 for a nonnegative x, 0 otherwise).

Three other functions deserve special mention. The first, `if(test_expression, true_val, false_val)`, returns either of two programmed values depending on the value of a test expression. This allows the creation of discontinuous and other special functions. The other conditional function, `until(test_expression, return_val)`, allows the execution of an iterative operation until the value of the test expression becomes negative. The histogram function `hist(intervals, data)` returns a vector representing the frequencies with which values in the `data` vector fall into the intervals given in the `intervals` vector.

A similar range of computational features is available in Eureka and TK Solver Plus. One major exception is MathCAD's matrix operators and functions. MathCAD's advanced mathematical functions include FFT and Bessel, which neither Eureka nor TK Solver Plus has. Additional statistical functions also place MathCAD at a distinct advantage.

An especially practical feature of MathCAD, considering its built-in functions for statistics and numerical analysis, is its ability to read and write ASCII data to and from a file.

MathCAD's unit conversions are also superior because of certain built-in fundamental units not found in Eureka and TK Solver Plus: L for length, M for mass, T for time, and Q for charge. When real units are defined in terms of these fundamentals, MathCAD performs dimensional checking of equations, indicating when the units don't match and what the units should be.

MathCAD is missing some capabilities found in TK Solver Plus. Chief among these is the ability to define algorithmic procedures with their own local variables. Another is the ability to map character information to numeric indexes, making possible constructs such as `molecular_wt = atomic_wt('carbon) + 2*atomic_wt('oxygen)`, where the labels correspond to atomic weights.

For optimization problems, you set up a "solve block," starting with the keyword `Given` and ending with one of two built-in functions: `Find` or `Minerr`.

Test Results

I tested MathCAD 2.0 on an 8-MHz PC AT-compatible computer with an 80287 coprocessor, 640K bytes of RAM, and a Hercules-compatible graphics adapter. To check its compatibility with other systems, I ran MathCAD briefly on a 4.77-MHz PC XT and a 16-MHz Compaq Deskpro 386. For comparison, I also ran TK Solver Plus 1.0 and Eureka 1.0 on the AT compatible.

I tried all three packages on systems of three and five nonlinear equations. All three found solutions, but timings varied significantly. For the three- and five-equation systems, timings (in seconds) were, respectively, TK Solver Plus, 1.5 and 2.3; MathCAD, 1.9 and 4.6; and Eureka, 4.0 and 31.8.

On a system of four nonlinear equations involving five constraints, MathCAD took 3.3 seconds while Eureka took 4.2 seconds. (TK Solver Plus does not have the built-in ability to handle constraints.)

Finally, I tested the programs using systems of 9 and 20 linear equations. TK Solver Plus won, taking less than a second for each test. MathCAD was next with 2.9 and 14.4. Eureka took 14 seconds to do the 9 equations and couldn't handle the 20 equations (`too many constants`, it said). Using matrix operators instead of algebraic expressions (only possible with MathCAD), MathCAD found the solutions in 1.5 and 10.3 seconds.

In summary, for small systems of nonlinear equations, TK Solver Plus was fastest, followed closely by MathCAD, with Eureka close behind. For larger systems, the ranking was the same, but Eureka fell farther behind.

For constrained nonlinear systems, MathCAD was slightly faster than Eu-

continued

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PC AI Magazine (comparing QuickC to Turbo C), Fall 1987, by Brian Flamig, reprinted with permission.

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Alan Holub, Columnist, Dr. Dobb's Journal, October 1987.

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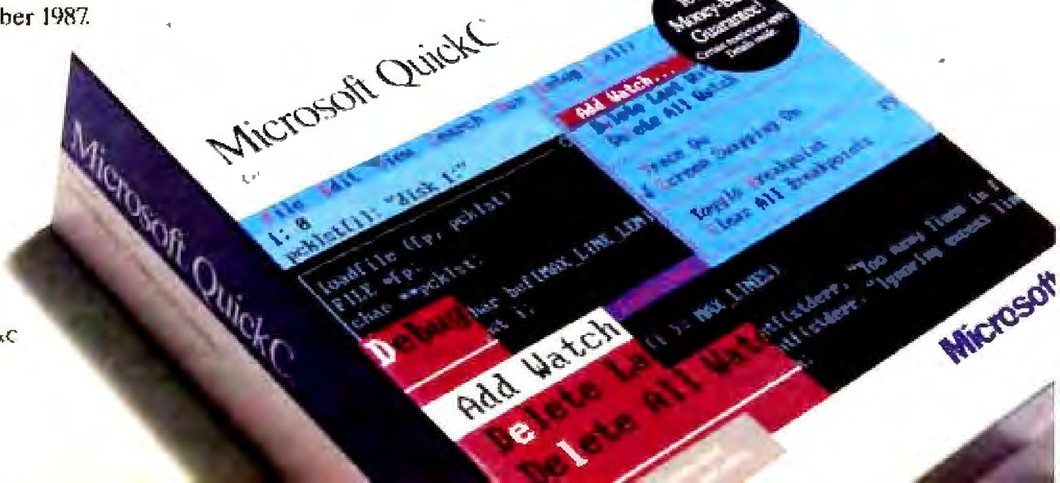

Circle 152 on Reader Service Card (DEALERS: 153)

reka. For linear equations, TK Solver Plus was faster than MathCAD and Eureka—but remember, Eureka is limited to small systems.

Room for Improvement

MathCAD's 290-page manual is well organized and thorough: 56 pages explain the use of the equation editing and entry features, and 104 pages describe computational features. A 7-page description of the numerical methods used is very helpful.

But while the program has on-line help from a 61K-byte file, it lacks context-sensitive help. Also, its help is slower than TK Solver Plus's, and it uses an awkward menu-selection system that involves typing arbitrary letters to find out more about topics. The company does, however, provide a toll-free number for customer support, and it publishes a lively quarterly newsletter for registered users of MathCAD.

I found other things that could be better in MathCAD. Its internal graphics model is too closely tied to the limitations of IBM's display graphics, effectively hobbling the output capabilities of higher-resolution output devices. Even though a laser printer may have variable-size fonts and 300-dot-per-inch resolution, MathCAD outputs to it at the same resolution and with the same limited font range as the display. (Inside text regions, you can use some of a printer's additional features by including escape code sequences with the text.) This shortcoming would probably be removed if MathCAD offered a versatile PostScript device driver in its list of printer drivers.

MathCAD's memory management is also less than ideal. Several times while I worked with a document containing two 1000- to 2000-element arrays, the program wouldn't complete a solution, telling me it was out of memory. MathCAD's originator, Allen Razdow, explained that each array must fit within a 64K-byte segment. This limits arrays to about 8000 elements. But smaller arrays can also cause problems after you've used the program for a while, because memory becomes fragmented. If the fragmentation is bad enough, eventually when you specify a calculation requiring more memory allocation, the program will not find enough contiguous memory space to hold a new array. (To MathCAD's credit, the program doesn't bomb; it just forces you to save the document and exit from the program. You can then restart the program with a nice new unfragmented memory space.)

To reduce the memory-allocation problem, Razdow suggested that I initialize large arrays at the top of the document. This helped considerably, postponing the eventual occurrence of the problem. On the positive side, MathCAD is able to use Lotus/Intel/Microsoft (LIM) expanded memory. Users who find they frequently run into the out-of-memory problem may find it worthwhile to add the extra RAM.

Slowpokes Need Not Apply

MathCAD really pushes a personal computer to its limits. If you've got the latest hardware, including LIM expanded memory and a laser printer for faster graphics output, here's a program that takes advantage of it all. For professional math work, I wouldn't try using MathCAD on anything slower than an 8-MHz machine equipped with an FPU. For educational purposes, MathCAD might run acceptably on an FPU-equipped PC.

If you have to choose between MathCAD and TK Solver Plus, consider your priorities: MathCAD is somewhat slower than TK Solver Plus, and it doesn't allow user-defined procedures. On the other hand, it gives you the ability to document your work, thus making it much simpler to formulate problems. MathCAD 2.0 succeeds at being a computer-aided scratchpad. ■

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RS/1 Research System

Harley P. Macon

Most statistical packages lack the long list of standard features found in RS/1, an integrated data-analysis package offered by BBN Software Products. RS/1 provides fully integrated data entry, graphical display, spreadsheets with master table and subtable capabilities, descriptive statistics, regression analysis, and modeling. A built-in programming language called RPL lets you package standard procedures (e.g., scripts, execs, and macros) and lets you add custom system enhancements and extensions. Although this integrated data-analysis package aims at research scientists and engineers, it is equally valuable to business people and other analysts. RS/1 is available for mainframes; minicomputers; workstations; and the IBM PC, XT, AT, and compatibles. The user interface is the same for all these implementations.

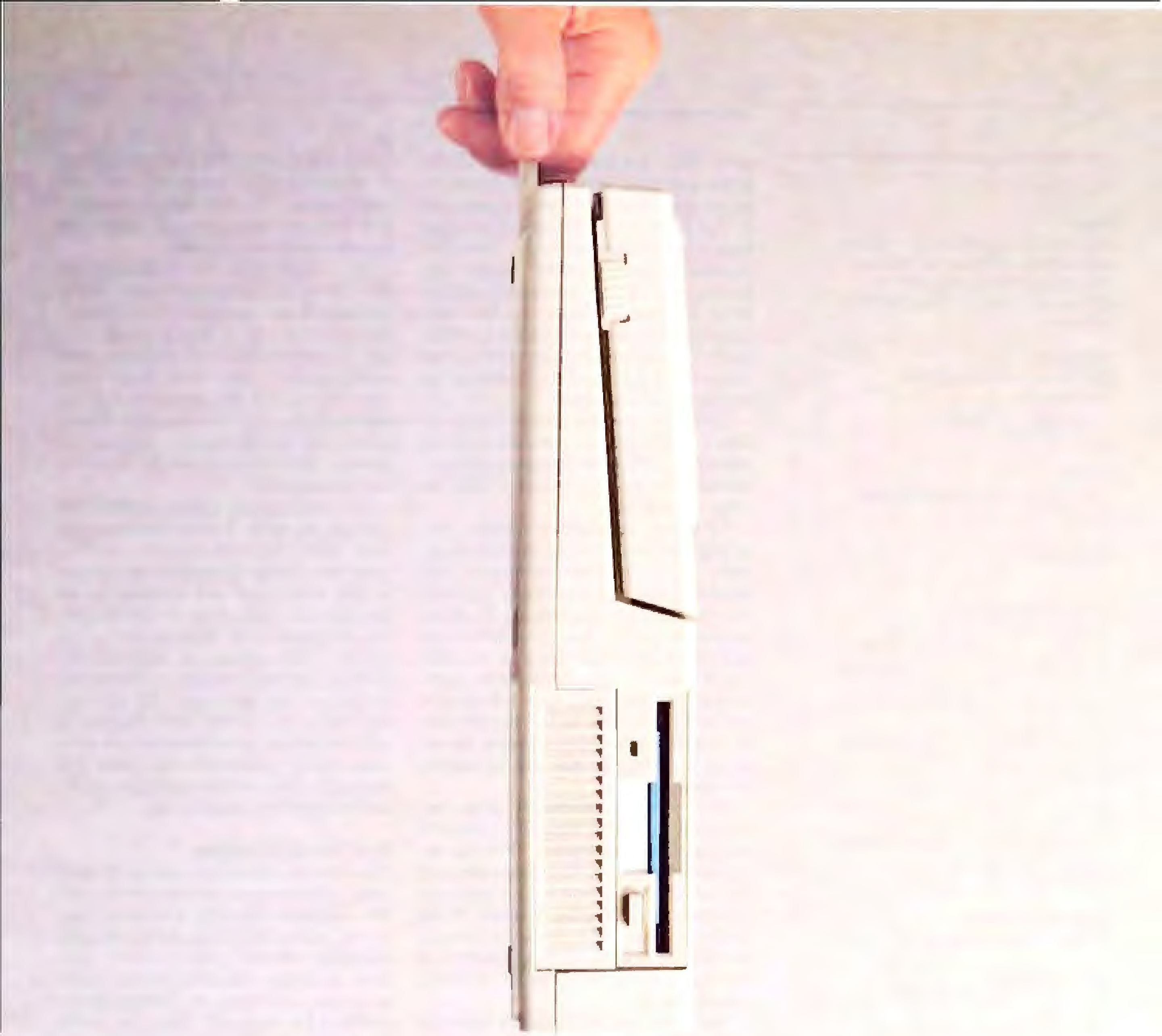
RS/1 version 12.1 for the IBM PC, XT, and AT requires a minimum of 512K bytes of RAM, a floppy disk drive, and a 10-megabyte hard disk drive. It supports a variety of displays, printers, and plotters as output devices (see page 173 for details). The $995 price tag includes maintenance for 90 days and "hot line" telephone support.

RS/1 comes with three reference manuals, *Installation Instructions*, and user and release notes for the current version that total about 1200 pages. It comes on eight disks in a plastic flip-top box. The documentation supplied is excellent, with well-indexed reference manuals and numerous examples. The only missing element is a good tutorial.

Installing the RS/1 software is easy, but you need to find 2.5 megabytes of free space on your hard disk drive. After that, installation is simple: You place disk 1 in drive A, type `A:RS1SETUP`, and follow the instructions. When installation is complete, you reboot the system. Proper installation of RS/1 is verified by running a utility called `$SYSTEMTEST`. If power is interrupted during your work, another utility called `RSFIX` repairs your RS/1 files.

The RS/1 package contains a demonstration program that I explored before consulting the manual. I discovered that the system generally forgives errors, but when I attempted to enter one more row of data into a table—more than the table expected—my Kaypro 16 locked up. I encountered no further problems. This exploratory effort convinced me that the individual elements of this package are easy to learn and use. However, the capabilities embodied in this package are so broad that you should expect to spend substantial time learning them. BBN pro-

continued



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RS/1 version 12.1

Type
Data-analysis package with integrated data capture, spreadsheet, statistical analysis, modeling, and graphics software and a built-in programming language

Company
BBN Software Products Corp
10 Fawcett St
Cambridge, MA 02238
(617) 873-5000

Format
Eight double-sided double-density 5¼-inch floppy disks

Language
C

Hardware Required
IBM 3270 PC, PC XT, PC AT, or compatible with 512K bytes of RAM, a floppy disk drive, and a 10-megabyte hard disk drive. Peripherals supported include 8087 and 80287 coprocessors, IBM and Hercules monochrome adapters, IBM CGA, EGA, and PGA graphics cards; IBM 5152, IBM Proprinter, and Epson FX and MX series printers; IBM 7371, 7372, 7372P, and 7375 plotters, HP 7470A, HP7475A, HP7550A, and HP7550AP plotters, expanded memory specification

Software Required
PC-DOS version 3.0 or higher

Documentation
317-page *Tables, Directories, and Models*
272-page *Graphics and Statistics*
275-page *Using and Writing Procedures*
28-page *Installation Instructions*
RS/1 Release Notes for the IBM PC version 12.1
PC Reference Card
License, warranty, and registration cards

Price
$995 (includes one year of maintenance telephone support)

Inquiry 903.

vides formal training in the use of RS/1 and its programming language RPL, but the basic functions are available for you to use and put to work in a few hours.

Editing Capabilities and Tables

RS/1 provides a variety of editing capabilities. A command-line editor lets you enter or revise command strings up to 512 characters long. You can choose a text editor as long as it obeys certain rules. First, you must be able to call the editor with the filename to be processed on the same line, and the text generated by the editor must not have embedded formatting commands (e.g., WordStar installed in "nondocument" mode). Unfortunately, the documentation lacks a list of acceptable editors, but the company did provide me with a list upon request. Once you define the name of your editor, RS/1 will invoke it whenever the command EDIT is issued.

RS/1 also provides a table and graph editor. Although each provides different capabilities, they are similar in syntax—learning one editor provides a basic familiarity with both.

RS/1 data structures are tables containing numbers and text. Formats (e.g., titles, column headings, row names, and footnotes) can be conveniently inserted. Row and column numbers are displayed as indexes to the table data but are not part of the data. Any entry in the table can be numeric, text, a command, a procedure (program) call, or a reference to part or all of another table. The table editor provides a convenient means for entering or changing data and formatting the tables.

RS/1 provides interactive table creation and data entry through a system of prompts called "dialogues." You can use dialogues for interactive data entry, or you can use the text editor for noninteractive data entry and strikeout mode. When using dialogues, RS/1 leads you through the process of table naming, creation of row and column headings (if desired), and data entry.

Table data can be selectively extracted with simple commands for the display or construction of new tables. Data within a table can be sorted, two tables can be merged, and a table can be appended to another (or a table can be transposed). You can use conditional expressions to extract information meeting certain criteria. All or any part of a table can be set to a predefined value or established by an expression using the SET command.

You can create a distribution table from data in another table. Such a table is a count of the number of occurrences of a particular value (or type) or the number of occurrences within a given range of values. As a default, RS/1 will automatically format data tables for display without your intervention, making the best possible use of space available on your screen or other output device. When desired, you can control presentation formats.

On-line help is available when you need to refresh your memory on some particular detail of a command. Typing a ? produces information about how to answer a prompt. Using the function key F1 or typing HELP brings up a subject-matter menu. You then choose a number from the menu and repeat this process to the necessary level of detail.

RS/1 directories are collections of RS/1 tables and other data objects. These data objects are managed with a directory structure that is syntactically similar (but not identical) to MS-DOS directories and subdirectories. There is no limit, other than disk space, to the number or depth of the directories and subdirectories. Directories can be displayed, printed, or plotted. Data objects can be added or deleted as desired.

Directories can be private, shared with a group, or public. Private directories are reserved for the owner in multiuser environments. Group directories are created by the owner and are intended to be shared by the work group. Public directories are provided by BBN as part of the system. They contain the functions for printing, plotting, and so on. The public directories are read-only, but you can copy them and modify their contents to suit your needs. In the multiuser environment, these distinctions are clear and necessary. They are maintained in the PC environment for compatibility.

Real-World Modeling

The user who creates a model is, in some sense, attempting to develop a tool to predict outcomes (usually real-world outcomes) as the data in the model changes. Modeling with RS/1 is conceptually similar to modeling with other products such as Lotus 1-2-3. First, you develop the algorithms for the model. Then, you define the model as a set of constants, variables, and expressions that are to operate on the data. Next, you create the model using the tools that are available. The process is often iterative, with many corrections and changes to the model, making ease of use a major consideration in this process.

RS/1 meets this criteria: It has very powerful modeling capabilities suitable for constructing models of scientific, financial, or other systems. Models have access to top-level commands, system procedures, and functions, as well as RPL and user-written procedures. You can create master models to control sets of submodels. This facility enables a large model to be decomposed into smaller components for model development, checkout, and computation, with fully integrated final results. This capability reduces both the development effort to produce a model and the computer memory needed for model operation.

A model contains a model table that defines it and a results table that contains

continued

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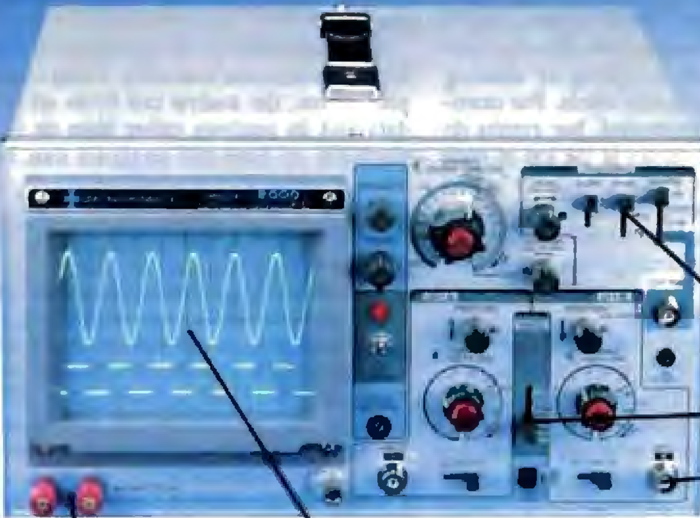

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- Capacitance: 2000pf–20 µf, 3 ranges
- Transistor Tester: 0°–2000°F
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the values developed by model operation. A model table can be developed interactively or noninteractively, just as any other RS/1 table. In addition to controlling the operation sequence of submodels, a master model can also issue special commands for execution either before or after processing the data for the submodels. An example would be the preparation of a bar graph to display results after a model run. The procedure for entering information is identical to that for any other table: The data entered is in the form of constants, variables, expressions, and commands (i.e., calls to procedures). Expressions entered may call for data from within the same table, or for part or all of the data from another table.

As with other tables, RS/1 keeps track of the models developed with entries in the directory. The table of formulas that describe the model are maintained in the directory with an object type of "table." Model results are maintained with an object type of "model." Once developed, models have a tendency to become outdated or to be used infrequently. RS/1 anticipates this with an `ARCHIVE` facility to back up files and allow their removal from the active disk file. A `DEARCHIVE` command is also provided for recovering those files when needed.

Easy Graphics

The old adage "a picture is worth a thousand words" is often true. A graphics display is the next best thing to a picture and, in many cases, better, since it focuses on specific details of interest. Fully integrated graphics functions that create and manipulate four different graphical data objects are provided. You use the `GRAPH` function for typical *x,y* graphs, the `BAR GRAPH` function for bar graphs and histograms, the `PIECHART` function for pie charts, and the `THREED` function for three-dimensional graphs.

Creating graphs with RS/1 is a breeze. The task is so easy you are encouraged to explore what can be done. With `THREED`, the many options available (e.g., hidden-line elimination, stereo views, and rotation about axes) provide their own fascination. Defining high-resolution images exacts a price in computing time. At least a numeric coprocessor, such as an 8087, or an AT-class machine is desirable for three-dimensional images.

You can use existing tables to provide data for the production of a graphical data object, or you can enter data through a dialogue. If you want to use a function to generate a graph, that capability is also available. Like the development of a table, the dialogue helps the user through the entry of the title, label, and scales for each axis, the source for data, symbols to be used to plot the data for each curve, and labels for each curve to be drawn.

The graph editor prompts for additional functions if more than one curve needs to be plotted. Once created, any of the graphics objects can be edited to meet your needs, such as adding or deleting curves or changing edit labels. For example, when first generated, bar graphs do not place actual values at the top of each bar, but such figures are easily added through the editing process. The consequence of this is a very flexible, easy-to-use tool for transforming data into graphic form.

Curve Fitting and Statistics

Curve fitting in RS/1 is approached in a pragmatic style: The discussion of techniques used avoids theory. Instead, you're advised on how to use each of the available tools. Measures of "goodness of fit" are defined, and reasonable values for each measure are stated. This is precisely the kind of advice that a user who may be rusty on theory is most likely to need.

The available techniques are simple linear regression (`LINE`), polynomial fit (`FIT POLYNOMIAL`), and nonlinear regression (`FIT FUNCTION`).

The `FIT FUNCTION` dialogue requests initial estimates for the variables. You can provide a single value for each or a range of values. A convergence criterion and a limit for the number of iterations (i.e., attempts to fit the function) must also be provided.

There may be more than one independent variable affecting the value of the dependent variable. For this situation, RS/1 provides a multiple regression function. Again, the underlying notion is similar. In addition, goodness-of-fit measures are provided that assist you in simplifying the model by suggesting which independent variables are causing "significant" changes in the dependent variable.

The RS/1 approach to statistics is similar to the techniques applied to curve fitting: The explanations, guidelines for use, and interpretations are pragmatic and easily understood. The most common statistical techniques are supported, such as descriptive statistics, t-tests, F tests, and nonparametric tests, analysis of variance and covariance, and contingency table analysis. Interfaces are provided to BMPD and SAS statistical packages that operate on mainframes for access to a more complete suite of statistical-analysis tools.

The data for a statistical analysis must exist in the form of tables or graphs; files can be imported to a table. Descriptive statistics are produced by issuing the command `MEASURE`, followed by the name of a table or the definition of a portion of a table. Specific descriptive statistics can be computed for all columns or rows in a table by issuing the appropriate command.

This same ease of use applies to all statistical procedures available. Using these procedures, the analyst can focus on the data and its analysis rather than on the problem of how the analysis can be accomplished.

An Analysis Package with a Wide Range of Capabilities

RPL is the fully integrated programming language for RS/1. It is a structured language designed to manipulate numbers and tables. RPL procedure statements are modeled after PL/I. Variables are self-typing, and variable-length arrays are supported with automatic paging to memory. Graphics are terminal-independent. Users who are familiar with structured languages, or with languages like BASIC and FORTRAN, will find RPL easy to assimilate.

RPL shares the same data structures as the RS/1 commands, and these commands can be embedded in RPL procedures. This facilitates the use of RPL with package scripts and at the same time extends the power of RPL. When special-purpose commands are needed, they can be developed with RPL and used like any other RS/1 command. Source-language debugging facilities and a large library of functions are provided to ease the programmer's tasks. For example, there is a function to read numeric input from the keyboard and to check that the input is valid (e.g., a digit).

RS/1 is a powerful, easy-to-learn productivity aid for analysts. Since it is available on a wide range of computers from personal computers to minicomputers and mainframes, it will be of special interest to research analysts and managers seeking to minimize data-exchange and training problems. RS/1 is a very comprehensive package with a full spectrum of analytic capabilities. You will not need all its features now, but they're there when you do. As I used the product, I became more and more enthusiastic with the level of integration achieved and the ease with which each new feature could be assimilated. Aside from the missing tutorial, this package rates about 9.5 on a scale of 1 to 10. ■

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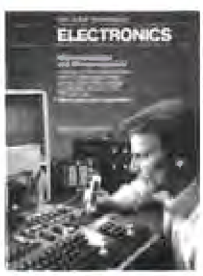

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Life after Las Vegas

Jerry Pournelle

Jerry tries out new products for the 386, a Mega ST, and a huge COMDEX

I've just come back from what was the biggest COMDEX yet. If there's a recession, the computer industry hasn't heard about it; despite horrible rain, Las Vegas was jumping. Floor space this year was sold out, and so is next year's show.

Shelly Adelson, chairman of the Interface Group that puts on COMDEX, was so enthusiastic that he's talking about buying some Las Vegas property and putting up a 1 million square foot convention hall to hold the overflow from the Las Vegas Convention Center.

There were thousands of exhibits, plus other groups huddled in suites, plus people like Adam Osborne doing demonstrations in the pressroom. As a result, I brought back a huge pile of stuff to be merged with the impossible quantity of unreviewed hardware and software that already fills Chaos Manor. There was so much, I wanted to sit down and cry. Clearly, something had to be done.

Don Hawthorne, a former assistant, once gave me a motto: "Every day, throw something away." I haven't been doing that, and I should. Anyway, today I got rid of four huge bags of stuff, mostly software from months to years past.

I hate to do that. People worked hard and long over each one of those products. Most of the programs are as good as much of the stuff that caught on and became a commercial success. Yet what can I do? I don't have the time to exercise 50 DOS shells, 75 disk-utility packages, a dozen BASIC compilers, any number of communications programs, structured editors, memory-resident spellers, baby spreadsheets, etc., etc.

Every time I dump something, I have the horrible feeling that I've just thrown out a potential Turbo Pascal; but if I don't throw some of it away, I will never get to anything new.

Interrupts Enabled

Here's an illustration of why I never have enough time.

While at COMDEX, I did some writing on the Zenith Z-183 portable—too heavy by half, but still my favorite of all the portables I have. When I got back home, I needed to transfer the files over to the Kaypro 386 and print them. That's usually simple. I just haul out Traveling Software's LapLink program. It comes complete with a four-headed cable—it has both a 9-pin and a 25-pin connector on each end—and the way to use it is obvious enough that I've never consulted the manuals.

This time, it didn't go so smoothly. First, I tried to use LapLink in the "Big DOS" window of DESQview. But that didn't work. I might be able to set up LapLink in its own DESQview window, but DESQview is pretty odd about communications programs.

The worst thing was that it *almost* worked. That is: LapLink has a way of detecting whether or not you're connected to another machine running LapLink, and even in the DESQview DOS window that seemed to be working fine. However, when I attempted to send files from the Z-183 to the Kaypro 386, I got a series of error messages.

Next thing was to quit DESQview and try again. This didn't work either, but for reasons that will probably never bother you: Traveling Software sends me automatic updates, and I had two wildly different versions of LapLink on the two machines. Eventually, I dug out two copies I knew to be the same version, reset both machines, and started over. This time, everything was fine.

LapLink continues to be a reliable way to move files, and at COMDEX, Traveling Software was showing DeskLink, an expanded version that links two MS-DOS computers of any size and, at least in their booth, transfers them at blinding speeds.

Once the files were transferred, it remained for me to print them. That's when my troubles really began.

I normally don't keep my Hewlett-Packard LaserJet Plus turned on because of heat and general wear and tear. That slows things down when I want to print, but not as much as you think, because between the LaserJet Plus and my computers sits Applied Creative Technology's Printer Optimizer.

This is a box full of memory. (It does a lot of other things, like translate codes, initialize the printer, and accept both serial and parallel input at the same time, but I've mentioned those before.) The Printer Optimizer comes on instantly when I turn on the juice. The result is that I can send over the file to be printed and get back to work while the printer is still warming up.

This time, though, when I started to print, I got `Printer Not Responding` from Q&A Write, and when I looked at the Printer Optimizer, its pilot was out. Inspection showed the switch was turned on, but the little power cord from the wall transformer was badly frayed. It wasn't delivering power, and my first attempt to fix it only made things worse; it sent out sparks.

This was, of course, on a Saturday night, with Monday deadlines. I had to do something.

The problem was the tip connector, which wasn't repairable. However, it looks like the connector used by the NEC and Tandy portable computers to connect their AC adapters. Maybe I could use one of those? But it's not smart to blindly connect up odd power sources without knowing what you're doing. Look in the

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.

manual to see what the power is.

I couldn't find that information in the manual. Well, OK, use a multimeter to measure the power output from the Printer Optimizer's power supply; but when I did that, I found it was 8 volts AC. That didn't seem reasonable; I'd expected DC. Of course, the output voltage wasn't printed on the power supply; there was only a part number. In examining it, I noticed that the little power supply box (the part that plugs into the wall) had become pretty hot before I detected the short. Was it supposed to deliver AC, or had a diode burned out?

I was ready to give up in disgust, but Mrs. Pournelle, with more patience than I have, went through the documents. Although there was nothing in the index or table of contents, a sheet in the back showed a drawing of the box; and in small lettering, it labeled the power input jack "8 volts AC."

Hurrah. I found an unused power adapter, cut off its tip connector, and attached that to the Printer Optimizer's power supply. Since it was AC, it hardly mattered which wire went to tip and which to ring. After that, everything worked fine, and it had taken me only about 2 hours to transfer the files and get ready to print. . . .

The moral of the story is simple: you never know when you'll need technical data. Companies that say you don't need technical specifications are either dishonestly trying to save a few bucks or just don't understand the situation. In the old days, computers came with very good technical specifications and description documents. The new ones often don't, and that's a step in the wrong direction.

VM/386

Many years ago, when we had only 8086 chips, I remember CompuPro's Dr. William Godbout giving me a lecture on what the 80286 chip would do for us. It turned out he was wrong—not because he'd misunderstood the implications of the chip—but because Intel never did manage to deliver an 80286 that worked up to specifications. To this day, the 286s come with several pages of bug reports.

There have been some bugs in the 386 chips, too; but not as many, not as serious, and, more important, not in the 286 functions. Real 386 chips you can buy right now will do all that the 286 promised and then some—or would do it, if anyone had the proper software.

Fortunately, we're almost there.

At COMDEX in 1986, I saw early "conceptual" versions of VM/386 from Softguard Systems. Steve and Ken Williams, Joe Diodati, and some others were writing a virtual operating system that would let you turn your 386 computer into about nine "virtual" IBM PC AT clones. This wasn't the perfect solution to the operating-system problem, but it would go a long way, since it provided real multitasking while also letting you keep a whole mess of programs instantly available at the touch of a hot key.

The only trouble was that they were trying to finance this marvel through sales of copy-protection software. This put me in a strange position: I wished them well on the 386 operating system, but I couldn't approve of the way they made their money. As a writer, I've nothing but contempt for software thieves (who like to call themselves "pirates"); but as a user, I can't possibly become dependent on something I can't back up.

As it happens, 1987 was the year the bottom fell out of the copy-protection market. A few publishers out there didn't get the word, but for the most part, copy protection of business software is history, and even publishers of games are going to an entirely different scheme. This left Softguard Systems without an income. The result was that VM/386 was sold to Intelligent Graphics, and most of the development people went with it; and they got it done in time for COMDEX 1987.

The demonstrations were impressive, much more so than Microsoft Windows because, unlike Windows, VM/386 runs all DOS software. At COMDEX, they were running a number of programs simultaneously. Each program had its own "virtual machine" with a full 640K bytes of memory, plus Expanded Memory Specification (EMS) memory. One machine had two copies of Autodesk's AutoCAD running in addition to other programs. I haven't had a chance to thoroughly bash VM/386. More next month.

386-to-the-MAX

VM/386—and PC-MOS/386, which I'm expecting Real Soon Now—are substitute operating systems using the power of the 386. There's another way to go. Qualitas offers a program called 386-to-the-MAX (I'll call it MAX386), which turns any 386 memory into the Lotus/Intel/Microsoft (LIM) EMS 4.0. If you've got a 386 and an ordinary memory board, you can run programs that understand EMS 4.0, and you won't need any special hardware.

MAX386 does other things. If you have an Intel 512K-byte motherboard with a 386, like on the older Kaypro 386s, MAX386 will backfill from your memory board so that the system will believe it has a full 640K bytes.

The program remaps your ROMs, particularly slow EGA ROM, into fast memory, in theory saving screen rewrite time. (I haven't noticed the need for that, and the problem is that they aren't ROMs anymore, meaning that they're vulnerable to being overwritten when you don't want them to be. Fortunately, this feature can be disabled.) There are other things, and it does all this in 2K bytes of low DOS memory (plus, of course, considerably more expanded memory).

I brought a copy of MAX386 home, and it does indeed work. I have a 512K-byte motherboard, and I normally use Quarterdeck's Expanded Memory Manager 386 (QEMM) to cause the system to believe it has 640K bytes. The QEMM package uses about 16K bytes of low system memory, so MAX386 ought to be preferable. When I substituted MAX386 for QEMM, it worked like a charm.

As far as I can tell, the EMS memory works reasonably well also. I say reasonably because while Lotus 1-2-3 seems to work fine with this, Ready! doesn't. To be fair, Ready! didn't work very well with my former (Above Disc) software emulation of EMS either; I'm told that older versions of Ready! (like mine) write all over places they shouldn't, and it's pretty hard to make it work properly.

The Qualitas people tell me their program will work with DESQview. Maybe so, but I couldn't get it to. Quarterdeck's Gary Pope is aware of MAX386 and says that early versions didn't work, but he thought the problems were ironed out. By the time you read this, they should be. The advantage of MAX386 over QEMM is that it's smaller, and you can open a window and load it with programs that use EMS 4.0. In any event, MAX386 works fine with reasonably well-behaved EMS programs, and it's a lot cheaper than buying a new board.

Sota MotherCard

There are 10 million IBM PCs and PC XTs out there, and while every one of them is more powerful now than when it was purchased, they're all obsolete by today's standards. The problem is what to do with them.

The best solution I've found so far is the Sota MotherCard 5.0, which drops into your PC or XT. It comes with a DaughterCard that can contain up to 4 megabytes of EMS memory, an optional 80287 math chip, and an AT BIOS and clock. Installation is simple.

This isn't just an accelerator card; it pretty much turns your PC into an AT clone, so much so that at COMDEX, Sota's Alan Hsiao was demonstrating an XT with a MotherCard running OS/2. You can't get much more AT-compatible.

My advice is, if you've got an old PC, buy a new power supply of at least 150 watts—they're advertised all over the

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place—and replace the smaller one that came with the machine. This takes less than half an hour. Then get a good hard disk drive kit. The best ones I've seen come from Priam, but plenty of others are out there. Install the hard disk drive. Then add the Sota MotherCard. The result will be fast, and it's a lot cheaper than buying a new AT. Recommended.

Sota also has a 386 card to put into your AT compatible. This thing runs so fast I could hardly believe it: In one benchmark, the Compaq 386 scored a rating of 3.5 versus a normal IBM AT's 1.0; an AT with the Sota 386 card ran at 5.6! The Norton SI (system information) rating was 31.6, which is actually as high as that index can go. I confess I am anxiously awaiting that card.

Atari Mega ST

Atari intends to go after the U.S. business market in a big way. The company is already accepted as a leader by the European business community. The original 520ST and 1040ST machines give more bang for the buck than anything else I'm aware of.

Given David Small's Magic Sac (and the Atari monochrome screen), you can make any ST run most (older) Macintosh software. Data Pacific also has a new Translator box that lets you run Macintosh software directly from its original disks. Meanwhile, there's plenty of business software being developed for the ST itself.

There are word-processing programs like Regent Word, and if you're used to WordPerfect, the Atari ST version runs as you'd expect it to. A lot of software runs better on the ST than on PCompatibles, because the Atari handles graphics better, and some programs are just easier to use with the GEM interface than with PC-DOS. A good example is Zoomracks, a data-storage-and-retrieval program that emulates the older card-based Execu-Scan system I formerly used. Zoomracks has a lot of similarities to HyperCard and positively cries for a mouse.

The Atari's monochrome resolution (640 by 400 pixels) is better than the Macintosh's, and it has a larger screen to boot. The Atari's color in "medium resolution" is the same as the IBM PC's CGA (see table 1), but the system hardware allows clever tricks to get a lot more colors onto the screen.

Antic has a program called Spectrum that does unbelievable things to Atari color, making it hard to distinguish it from the Amiga. The Atari 520ST and 1040ST machines sell at attractively low prices. In a word, the Atari ST line has a lot going for it.

The Mega ST is Atari's new and improved version of the ST. You can get 2 or 4 megabytes of memory, which is twice the Macintosh SE's capacity. If you get a Mega ST, the Mega 4 is probably what you ought to buy; it's pretty hard to upgrade the Mega 2 into a 4. I know of no programs that can use the full 4 megabytes, except Antic's Cyber family of three-dimensional CAD and animation software, which turns the Mega ST into a desktop video workstation. They do things little short of amazing.

Unlike programs that run under PC-DOS, there's no inherent reason why an Atari ST program can't be a megabyte in size and access another 3 megabytes of data. The Mega ST also has a blitter chip to speed up graphics. The resulting color output isn't quite up to the standards of the Amiga, but it's sure good enough for most people. I've just put in the best part of a week playing with the Mega ST, and I like it.

There are real problems, though.

First, it's overpriced. By the time you get a Mega 4 with a hard disk drive, you'll have paid nearly as much as you would for the Macintosh SE, and there's a lot of Macintosh software out there. Up to now, Jack Tramiel's Atari machines have been competitive in price and performance; I'm not so sure that's true of the Mega ST.

There are also compatibility problems.

continued

Table 1: *Standards supported by the Orchid TurboPGA board. Emulation of CGA, MDA, and HGC is achieved through software commands; PGA and EGA are native to the hardware.*

Name	Resolution	Colors	Palette	Horizontal scan	Vertical scan
PGA	640 x 400	256	262,144	30.5 kHz	60 Hz
EGA	640 x 350	16	64	21.8 kHz	60 Hz
CGA	640 x 200	4	16	15.75 kHz	60 Hz
—	320 x 200	—	—	—	—
MDA	720 x 348	—	—	—	—
—	80 x 25 characters	(mono)	—	18.4 kHz	50 Hz
HGC	720 x 348	(mono)	—	18.4 kHz	50 Hz

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Some of the software written for the 520ST and 1040ST blows up on the Mega ST. As an example, Strategic Simulations' Roadwar Europa is not copy-protected and instructs you to play only with a copy. Fine, but when I formatted a double-sided 3½-inch disk, I kept getting bombs (the Atari's rather whimsical system failure message) at disk access.

I finally erased that disk and reformatted it as single-sided, after which I got fewer bombs—but it still crashed several times during the course of the game. MichTron's M Disk program doesn't seem to find all the extra RAM in the Mega ST. It will still let you make a big RAM disk. I've had glitches with some other programs (mostly games; games are a pretty good way to test a machine).

The Mega ST has a new version of the Atari ROM TOS operating system. It fixes some bugs in the old TOS; for example, the 520ST and 1040ST used to forgive writing beyond the end of memory, while the Mega ST sees that as a bus error. Unfortunately, although it isn't the machine's fault (programmers have no business being that sloppy), this and other "fixes" introduce more incompatibilities with the 520ST and 1040ST.

I don't want to exaggerate. Well-written software has no compatibility problems, and most of the older stuff will be fixed in new versions. The real problem with the Mega ST isn't its compatibility, but its price.

Education and the Atari ST

When you think of computers in education, you naturally think of Apple; but in fact there's an awful lot of good stuff out there for the Atari ST. Arrakis Advantage has designed a whole series of programs to teach subjects like statistics. They use computer graphics in a very clever way to hold the student's interest.

MichTron has a whole line of ST software, from desktop utilities like M Disk and MichTron STuff that almost everyone will need, to games—Time Bandit still has my vote as having the most exciting graphics I've seen on a small computer game—to educational programs like AB Zoo, which teaches keyboarding to children ages 3 to 6.

Mrs. Pournelle spent an hour playing with AB Zoo and kept calling me over to look at the graphics. Her favorite was the little vampire bat that pops up when you correctly find the *V* key. We did get a bit weary of the music; there are only three tunes, and after 10 minutes of "Twinkle, Twinkle, Little Star," you wish mightily for a nova. Of course, you can always turn the sound off.

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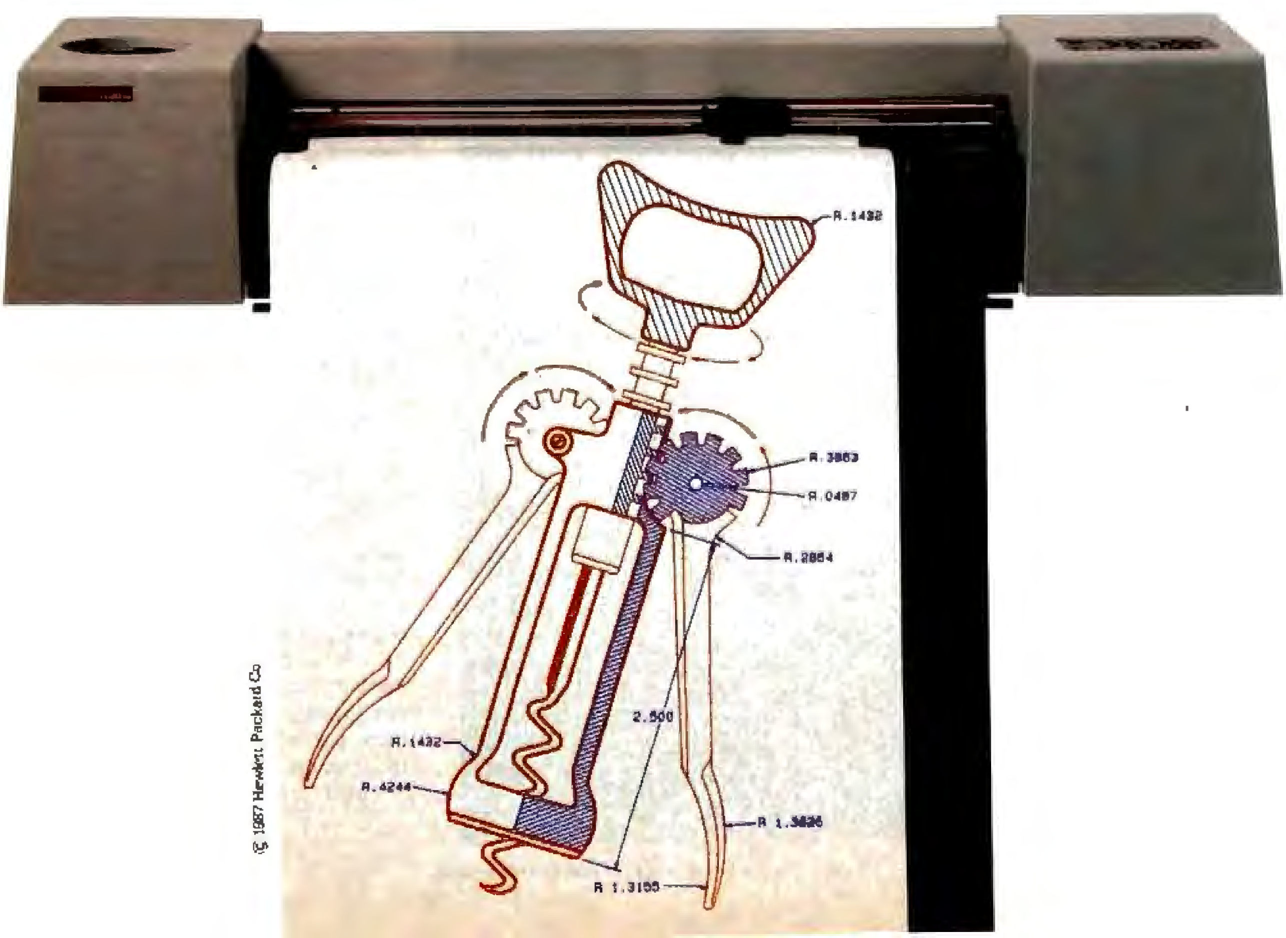


Invasion, also published by MichTron. This game is similar to Type Attack in that you see a city, with words falling onto it; as you type the letters in the words, a laser shoots them off the screen. You're supposed to get them all before a building is hit, and the only way you'll do that at the faster levels is to learn touch-typing. There's no way you can stare at the keyboard.

We found a glitch in this game, in that it wouldn't let us create a new typing practice vocabulary although it said it would; we got cherry bombs on both the Mega ST and the 1040ST when we tried to save the new file, and once again I think it was because we formatted the playing disk as double-sided. It's not a critical problem; since the program expects the new vocabulary to be in a standard ASCII file, you could actually create one with any word processor.

Invasion also has a math section: The enemy attacking your city is an equation like "3 + 5 = ??" or "4 * 7 = ??". You're supposed to type all of it in, not just the right answer. The constant repetition tends to burn the addition and times tables into your brain all right; the problem is that on the Atari ST keyboard, you have to use Shift keys to produce the + and * signs and so forth, and that's not easy given the time you have before the enemy blows up part of your city. Alas, you can't make up your own equations; Mrs. Pournelle thinks she could do some better ones. For the price, though, Invasion is quite a bargain.

That brings us to Walt Disney Personal Computer Software from Sierra On-Line, specifically Donald Duck's Playground. This says it's for ages 7 to 11, which is silly; I'd expect 4-year-olds to like it, and kids over age 9 might tire of it fairly soon.

The game was ported over from the IBM PC by a programmer who didn't understand the Atari ST. In order to play it, you must plug the mouse into the Atari ST, then, after the program boots up, unplug the mouse and put the joystick into the place the mouse was. Given that on the Atari ST the mouse and joystick ports are under the machine, this is one miserable task. There are separate ports, and you can keep both the mouse and the joystick plugged into the Atari ST; but Sierra On-Line didn't bother studying the machine and requires that the joystick be in port 0, where the mouse usually resides.

Once you get the game up and running, though, it's pretty cute. Donald Duck wants to buy equipment for a playground. First, he has to earn money by working in a series of amusing if a bit tedious tasks. Then he can go buy things, paying for them and making change as required. Finally, he can go inspect the new equipment that has been delivered to the playground and watch his nephews jump, slide, and otherwise enjoy themselves.

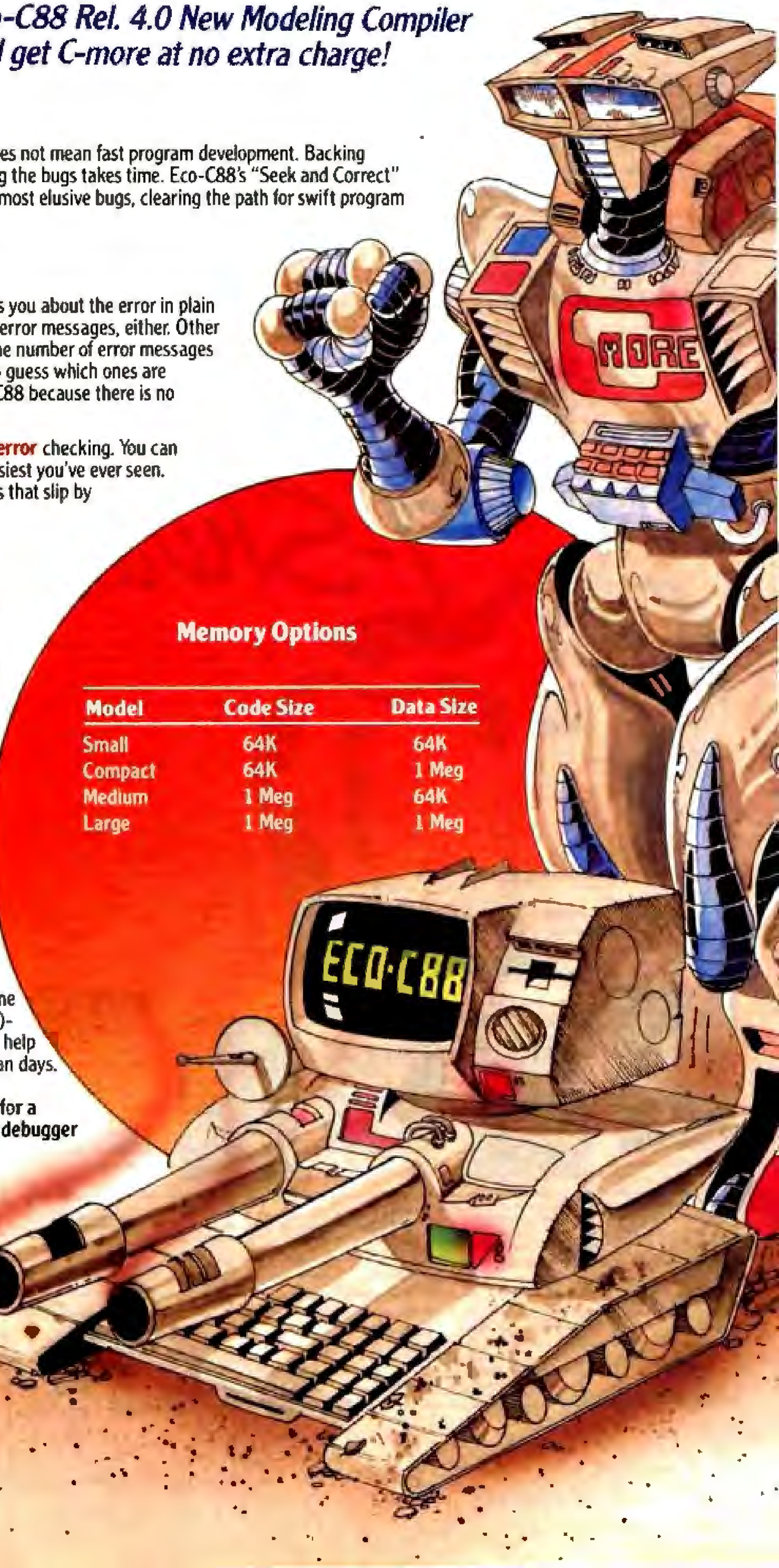
I can't guarantee how long it will hold a 7-year-old's attention, but it kept Mrs. Pournelle and me amused for hours.

Languaging Up

Given what you get for the money, I don't think there's a better home/educational computer bargain than the Atari 520ST. The question is, how will Atari fare in the business machine market?

The machines are technically good enough. There are some drawbacks. I've already mentioned price. The Mega ST has a detached keyboard and a more professional look than the original STs, but, alas, the Mega ST still has those "designer" function keys slanted to look just as cute as a bug's ear while making it hard to use them properly. The mouse and joystick still plug in awkwardly, and there's only the one serial port. No internal modem and no slot. No math chip. Some of these limits may be overcome by

continued



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third-party hardware developers. Some won't be.

Atari uses Digital Research's GEM as the main user interface. I could learn to prefer GEM to DOS, and many already do. My pet peeve is that the silly drop-down menus drop whenever the cursor gets too close to the top of the screen; but there is, I'm told, a memory-resident program that fixes that, so that you have to click to get the menu. (GEM originally had pull-down menus like Xerox, Lilith, and Macintosh, but Digital Research was frightened away by lawyers.)

The Atari ST is an extremely powerful tool, certainly capable of doing business computing; indeed, as I've reported, the Europeans are doing just that.

The Mega ST's future will not be decided by Atari alone (although the company does control the price, of course). The real answers will come from the hackers and software developers. If they'll produce software that will use the machine's capabilities, Atari will be in fine shape.

There are signs that the software is coming. I saw a lot of it at COMDEX. I also saw the languages developers will need.

Barry Workman and my son Alex of Workman and Associates demonstrated their new FTL Modula-2 compiler for the Atari ST at COMDEX. There hasn't been a lot of applications software written in Modula-2 in the IBM PC world. There are several reasons for this. One big one, I think, is Turbo Pascal, which has had so many features added that it's more like Modula-2 than Pascal anyway.

In my judgment, Modula-2 is still the language of choice for most large projects, particularly in situations where a number of programmers have to work more or less independently. Workman's version for the Atari ST is set up to work with GEM, and the optional Editor Toolbox gives source code for writing your own applications.

FTL Modula-2 produces code that runs acceptably fast on the ST: a Modula-2 version of my very math-intensive matrix benchmark (see the August 1987 BYTE, page 243) runs in 63 seconds on the ST. Typical times on a Zenith Z-248 without a math chip are about 80 seconds. I'll be much surprised if there aren't several Atari ST applications programs written in FTL Modula-2 by this time next year.

There's also HiSoft BASIC, which is "interactive compiled." It's fast (running my benchmark in about 60 seconds) and reasonably compatible with Microsoft Compiled BASIC 3.0 for the IBM PC. (It doesn't have records and some of the features of Microsoft QuickBASIC 4.0, but then nothing else does either.)

HiSoft BASIC supports recursion and has libraries for interfacing with GEM. It's powerful enough to write business applications with. I'm still doing all my accounting with programs I wrote in 1978 in Compiling CBASIC (originally CP/M, later recompiled for PCompatibles), and HiSoft BASIC for the Atari ST is as powerful as CBASIC was.

I'm told there's a Prolog for the Atari ST, but I haven't seen it yet. I sure would like to. Then there's Lisp.

John McCarthy wrote Lisp (officially, that stands for list processing, although Lisp detractors say it stands for lots of insane stupid parentheses) while a graduate student in the 1950s. It has since become the language of choice for much of the artificial intelligence community, largely because Lisp doesn't see any differences between data and program. That makes it easy to write programs that modify themselves. Of course, once you've done *that* you could end up with a smart program, but unless you're pretty smart, you'll probably generate a colossal mess.

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Some extremely interesting programs are written in Lisp. Many were developed at universities with public money and thus ought to be in the public domain. Some are perhaps obsolete: The first spelling-checker program I ever used was developed at MIT for the DEC PDP-10. I thought it wonderful at the time, but there are much better ones now. Others, like MACSYMA, which does symbolic algebra, have enormous potential.

Lisp is a memory hog. It has to be, since it does a lot of its work by recursion (a technique in which a function repeatedly calls itself). John McCarthy used to be fond of saying that Lisp doesn't really get interesting until you have a fast machine with 4 megabytes of memory.

The Atari ST is a fast machine that can have 4 megabytes of memory. I know of only two Lisp programs for the ST: Metacomco's Cambridge Lisp and a program written by BIX Senior Editor Dave Betz ("dbetz" on BIX). Both are limited. I'd sure be interested in seeing a good MacLisp or some such for the ST.

A Picture of the Future

When IBM brought out the PC, they deliberately didn't build in video hardware. You had to buy a card that would output either monochrome or color graphics. This was pretty clever given the advances that were (and still are) being made in video display technology, but it sure made for confusion since there was no real standard.

About the same time, Zenith put both RGB and composite color in their machines, with the latter able to drive a monochrome screen as well. They still do that on their laptops. The color on the Z-100 dual-processor machine was better than anything IBM had for quite a long time, just as the Z-100 was a better machine than the IBM PC. It didn't have a detached keyboard and had some other minor problems, all of which would have been fixed, but the Z-100, like a lot of other good machines, was burned up in the mad race to PCompatibility.

IBM's monochrome and color weren't very good, and it wasn't long until third parties like Paradise, Orchid, and Hercules brought out improved video boards with far better graphics capabilities. However, none of the early PCompatible color capabilities were good enough for writing books. The edges of the letters were too fuzzy, and the whole display lacked crispness. For serious writing, you had to stay with monochrome or avoid the PCompatibles altogether.

Then came EGA, which required a monitor with a higher sweep frequency, and at first there were problems running software written for the older IBM CGA standard. The monitors and EGA driver boards weren't cheap, but EGA was certainly good enough for professional writers. For that matter, it still is. I'm still using it for all my writing, including this column. EGA was responsible for bringing a number of writers into the PCompatible fold.

The problem was that EGA boards weren't well-designed. The chips don't have readable registers, which means that although your software has to be written to take advantage of EGA, the program can't get feedback: there's no way to tell what state the EGA board is in. That can lead to some odd displays. Faults and all, though, EGA was good enough that it became the business color standard, and a lot of companies began producing EGA monitors.

It was a short-lived standard. I don't suppose we can say EGA has actually been replaced, but we can all see the handwriting on the wall. When IBM announced VGA, the new "standard" for the PS/2 bus, they didn't say they were abandoning EGA, but they didn't say they were going to support it, thereby in effect pronouncing EGA's death sentence. In a few years, many expensive EGA monitors are going to be somewhat obsolete. It's a pity they can't be modified so they can be used with the new VGA graphics, but they can't.

Notice that I said "obsolete" and not "surplus." Readers of this column will recall that for a year now I've been using an EGA system with Intecolor's MegaTrend 19-inch EGA monitor. I still love it. That monitor is more than good enough for just about everything I want to do, and EGA will continue to be good enough for what people bought it for. However, graphics technology moves on, and I'm interested in keeping up.

Electrohome and TurboPGA

The upshot is that I have a new monitor, an Electrohome ECM Vari-Scan. This accepts everything from CGA up through the new PGA systems. Like the NEC MultiSync monitor, the ECM Vari-Scan accommodates just about everything you throw at it.

Surprisingly, the monitor is slightly smaller—though heavier—than the MegaTrend. In EGA mode, the screen quality is comparable to the MegaTrend's; my subjective opinion is that the MegaTrend's display is crisper and the colors a bit more vivid, but there's not that much difference.

In PGA mode, this thing is gorgeous. We're driving it with the Orchid TurboPGA board. This board, like the Electrohome monitor, accepts all inputs from

continued

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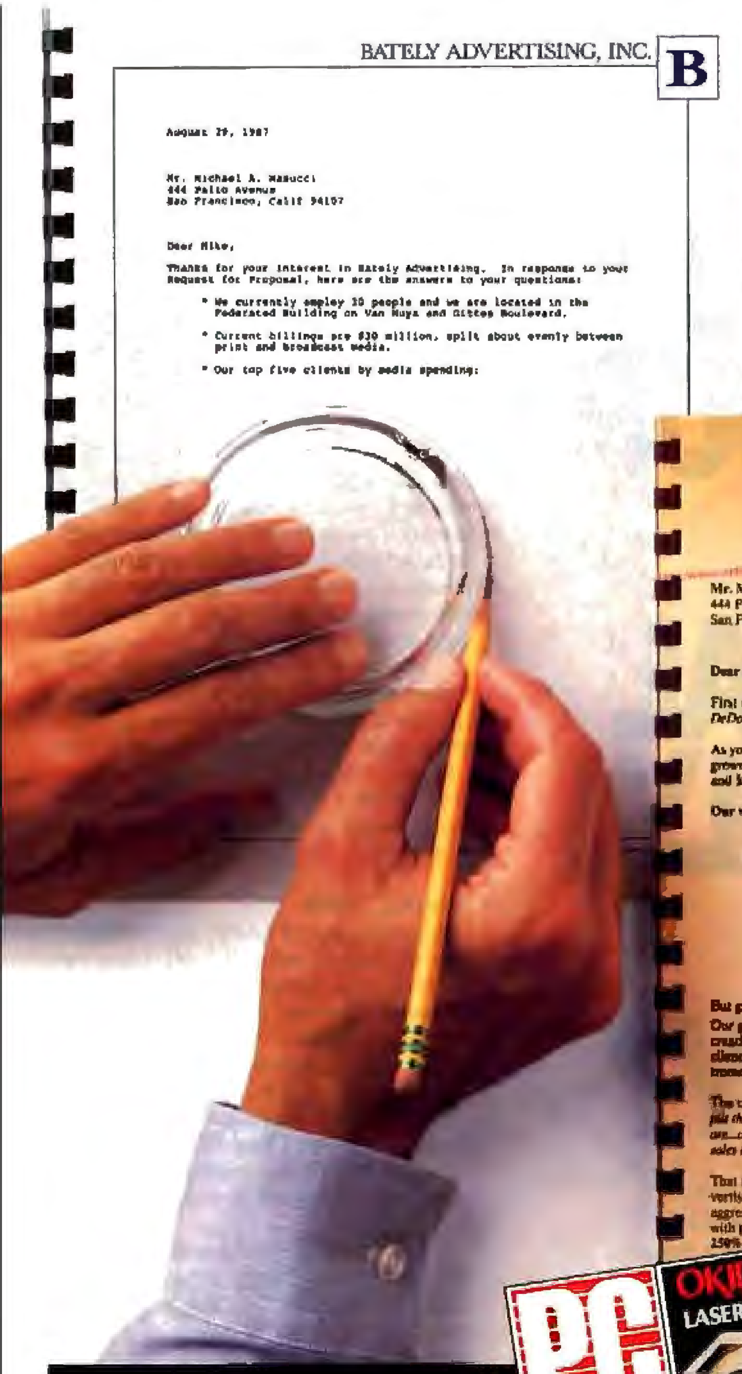

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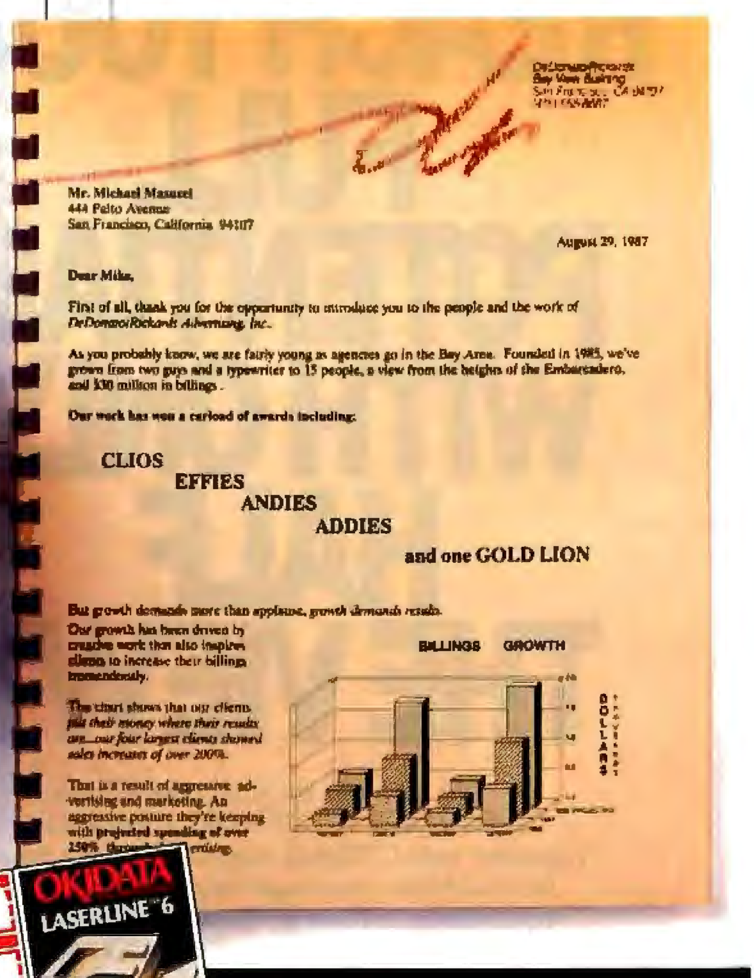

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CGA up to PGA. There's a software toggle to go from EGA to PGA, since most programs, including DOS, can't talk in EGA. (The PGA board has separate screen memory for EGA and PGA; when you toggle from one to the other, the images aren't erased.)

Once you're in PGA mode, the display is little short of amazing. My monitor came with a disk full of three-dimensional demonstration images, like architect drawings of houses in shaded colors and pastels, complete with landscaping and trees; car bodies; robots; and the like. Any of those pictures would be good enough to photograph and use as presentation slides.

For that matter, you can pipe the output from the board into a box that will make Polaroid photographs directly. I can see how this could dramatically increase productivity for anyone involved in color image presentation.

My TurboPGA board came with PGA Palette, a paint program that lets you mix up any colors you like; see table 1 to get some idea of just how rich that mix can be. Most of the images on the demonstration disk were drawn with that, although some were done with RIX's EGAPaint. RIX, in case you missed my earlier remarks, makes about the best IBM PC paint programs around. They're always upgrading, and each upgrade is more spectacular than the last. The latest is EGAPaint 2005.

PGA is spectacular, but it's not perfect yet. Unlike EGA, PGA has square pixels, which helps a lot, but diagonal lines still have some slight sawtooth texture.

The TurboPGA board solves one annoying problem. Some older software—like very old versions of Lotus 1-2-3 and games like Star Flight and Crush, Crumble, and Chomp—was written well before EGA existed, and not only don't use EGA graphics (most games still don't), but can't even talk to an EGA board. You can get software patches for many of these, but it's still annoying. Orchid supplies a program that you run to tell the TurboPGA board to expect CGA output, after which there's no problem.

You may not need full PGA capability, in which case EGA is good enough and will be for a while. On the other hand, if you need a new monitor, you'd probably be smart to buy one that can accept multiple sweep speeds. Color graphics are getting pretty spectacular, and it would be wise to be ready for them.

There's one more feature to the Electrohome monitor: you can get a box that accepts two video inputs, say from a VCR and a cable, and instantly switch from the computer input to that, turning your monitor into a TV set. The instant switching is useful if you're pretending to be working.

Winding Down

I'm running out of space, and as usual I haven't touched half the stuff I laid out for review. In particular, there's Scandinavian PC Systems' Readability program for PCompatibles. This thing analyzes text in truly wonderful ways and is little short of amazing. More next month.

I've also got Smalltalk for the IBM PC. Smalltalk, Prolog, and other nonprocedural languages are coming into their own, and it's important to keep up with them.

I'd intended to do a complete exposition on games. Many game designers seem to lose sight of the notion that games are supposed to be fun. They may also be educational. In my judgment, they shouldn't be—as some I've seen recently—primarily vehicles for designers to show how much more clever they are than their customers.

That is not the problem with Earl Weaver Baseball (I have an Amiga ver-

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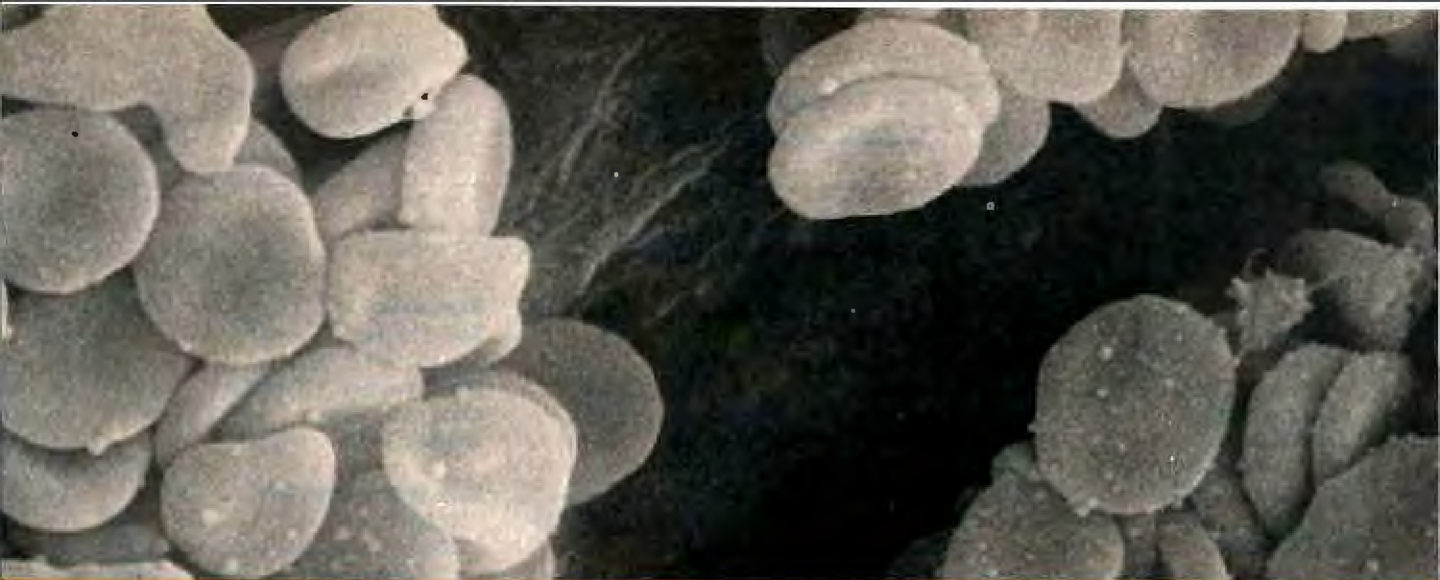

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sion, but there are others). If you're a baseball nut, the only problem the game has is that you'll spend half your life playing it. I know my kids have. If you're interested in hit-and-run, when to bunt, and that sort of thing, you can painlessly learn more about baseball strategy from Earl Weaver Baseball than from a dozen books on the subject. Recommended for baseball fanatics.

My personal game of the month is Wizard's Crown from SSI for PCompatibles. This is a sword and sorcery adventure game that has really nice combat resolution—you can play down to a blow-by-blow battle—with good CGA graphics and an interesting adventure quest with puzzles.

The book of the month is *From C to Modula-2 and Back: Bridging the Language Gap* by Claude Wiatrowski and Richard S. Wiener (John Wiley and Sons, 1987). This thing gets technical in spots, but if you know either language and want to know about the other, this is the book to get.

Now if I can just find a place to put all this unreviewed stuff. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

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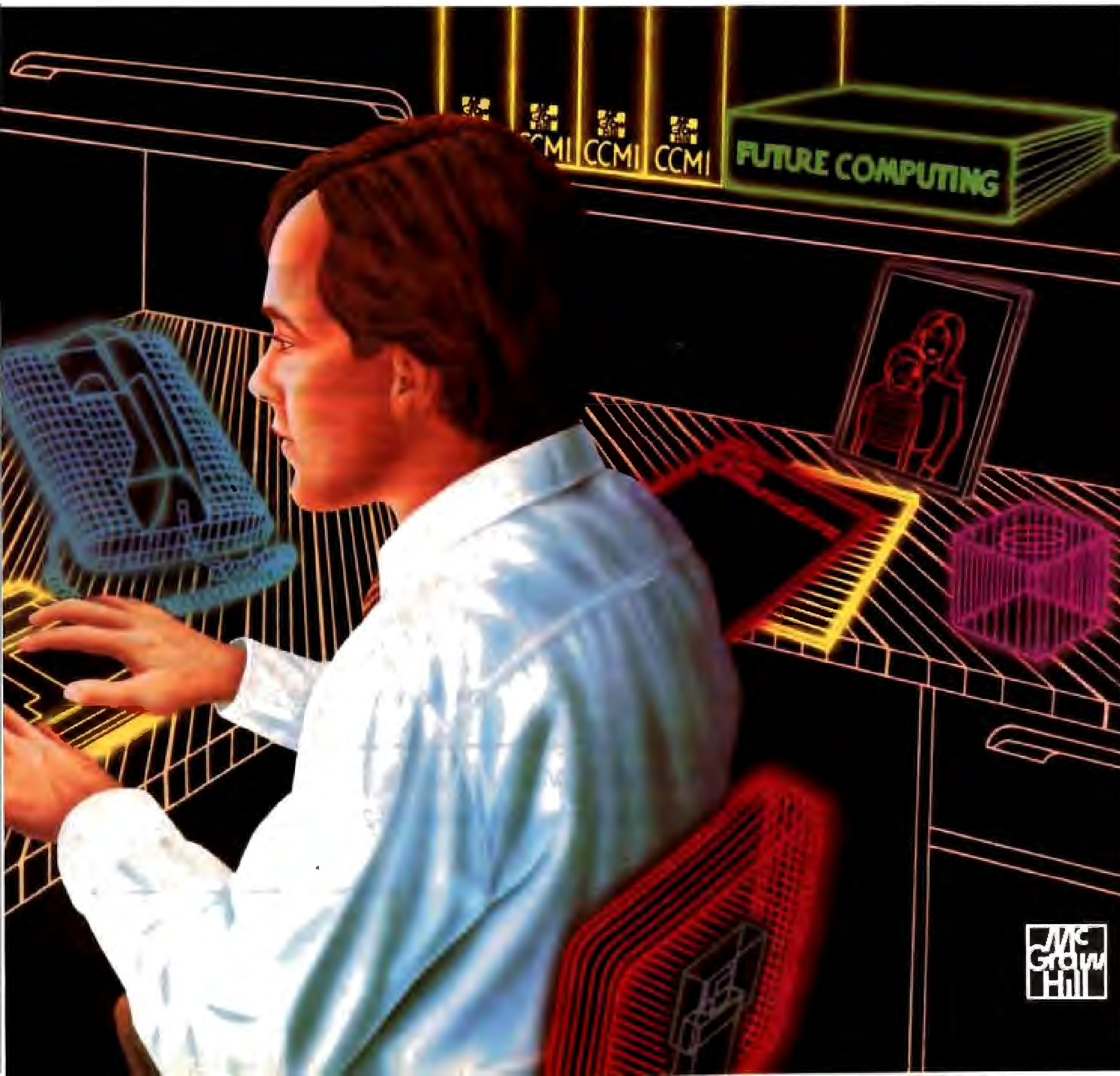

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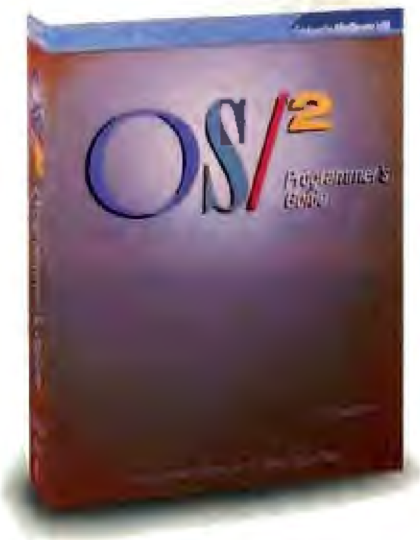

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Shortcuts for Simplicity

Ezra Shapiro

MacInTax and TaxView, a brainy printer cable, TopDOS, and PowerStation

I was horribly late submitting this column to BYTE; it has been one of the toughest I've ever written. For some time now, I've wanted to make a strong statement about what I see happening in the MS-DOS world. I've tried analogies, anecdotes, and parables. Nothing has worked. Were I not using a word processor, I'd be up to my knees in crumpled paper.

To be blunt, I'm deeply disturbed by both OS/2 and the rapid disintegration of standards in the IBM PC arena. Software developers and software users alike are going to be hurt badly. Even if OS/2 and its graphic interface, the Presentation Manager, are as spectacular as Microsoft and its hardware clients claim, the result is going to be confusion and bitterness all around. I throw out the following points in no order of precedence.

OS/2 is going to create at least two tiers of IBM PC users. Since not even Microsoft Windows 2.0 runs acceptably on an 8088-based computer, millions of people who have invested billions of dollars in both hardware and software are going to feel abandoned. You can't just declare that kind of capital investment obsolete without major repercussions.

MS-DOS will linger for a long time, perhaps spinning off into an independent world of its own. OS/2 and MS-DOS are different enough that people won't be able to just switch back and forth between operating systems. Each one will create its own culture, and there will be inevitable clashes, if only because OS/2 software won't run on 8088-based machines.

The original IBM PC brought with it, simply by its dominating presence in the microcomputer market, a batch of standards that made life with computers immeasurably easier. Finally, we had a standard disk format. There were standards for monochrome and color video, character sets, add-in cards, and even cables. MS-DOS became the operating system of choice.

It took a while for the industry to fall in line, but when it did, there was a collective sigh of relief. With standardization, prices for components plummeted, and low-cost equipment suddenly put computing within the reach of us all. Unfortunately, those standards have already begun deteriorating.

The IBM line now boasts three largely incompatible disk formats, six video standards, and three slot architectures. If you throw in third-party alternatives, extended memory, networking, pointing devices, optical storage, and memory-resident-software configurations, the potential disorder is incredible. What MS-DOS had given us was the glue to hold this fragmenting universe together. Until now.

Disarray accompanies any sudden change. On the software side, we see a whole gaggle of companies pushing operating systems and operating-system extensions far more aggressively than at any point in the past. Control programs for machines from 8088s to 80386s have captured a growing market. New life has been breathed into the struggle to establish Unix and its relatives in the microcomputer community.

On the hardware side, a number of firms have announced architectures that diverge widely from the IBM PS/2 series.

What does this mean for applications software? Well, it will get tougher for developers. Compatibility problems are increasing at a fast pace, and that pushes up development time and expense.

Many companies that provide telephone support find themselves responding to questions about operating systems and hardware. I expect that pressure on support services is going to increase exponentially.

Users are going to foot the bill; it's hard to say whether the costs will be passed on in the form of price increases or in the number of bugs we'll have to catch on our own, but we'll pay one way or the other. And we'll have to be far more astute in choosing the products we buy; ignoring one teeny specification might saddle us with a useless purchase.

I have no solutions for any of this, and I don't oppose progress. I'm a technological junkie, and I love to see the state of the art advanced. I'm just saddened that this current step forward will be launched with a giant step backward.

Would we have been spared some of the headache if OS/2 had been delivered at the same time as the first 286-based computers began to ship? Probably. Can we minimize the personal hassle by deciding, early on, whether to jump on the OS/2 bandwagon or ignore it completely? Probably not. This whole mess is going to require every last one of us to become a guru, and I would rather have been left alone to just do my work.

There's a poignancy in this month's product selection. The overall theme is "making life easier." Ironic, isn't it, that the industry seems to be going out of its way at the moment to make life tougher.

Best in Both Worlds

Susan Morgan of SoftView has a nasty problem. The software her company sells has, at best, an abbreviated life cycle. The products are useful for less than 3 months, and then they fade away until the following year. By the time a reviewer has received a shipping version and evaluated it, it's too late to write about it and still be timely. So Susan Morgan twists

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P.O. Box 146069, San Francisco, CA 94114, or on BIX as "ezra." Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

editors' arms, desperately trying to get them to write about the products before they're actually released.

It's not her fault; blame the federal government. SoftView publishes income-tax software: MacInTax is for the Macintosh, and TaxView is for MS-DOS machines. The IRS doesn't release its official forms until January. The people at SoftView hustle like crazy to finalize their products and ship them to waiting customers around the country, and the whole cycle ends abruptly on April 15.

Though you're reading this in 1988, I'm writing it in 1987. I have not seen MacInTax or TaxView for the 1987 tax year. Nobody has. So I have to base my recommendation on the 1986 version of MacInTax, which is now ancient history.

To put it simply, MacInTax has been the hands-down category leader on the Mac. The program displays all but the most obscure forms on-screen and prints them perfectly on either the Imagewriter or the LaserWriter. They're linked and completely self-calculating; data entered in a form, or on one of SoftView's specialized worksheets, is automatically factored into your tax computations.

You are able to import information from spreadsheets or databases, as long as it's in tab-delimited text format (a standard transfer ritual on the Mac). If you want to play what-if games, MacInTax will flag your guesswork as estimates and let you search and replace the trial items when you get the real stuff. In short, MacInTax eliminates the brainwork from preparing your taxes.

I did my 1986 taxes using forms designed for Microsoft's Excel. Some of the schedules I needed were missing, and I couldn't get an acceptable printout using the QMS laser printer I've got hooked up to the Mac. I thus had to copy the figures off the Mac display and enter them by hand into the correct federal forms, a time-consuming nightmare.

I didn't get a chance to play with MacInTax until after I had filed. When I saw what it could do, I cursed my luck. This year, with sweeping changes in the tax code that are bound to make this the most confusing year in recent memory, I'm not going to be brave; I'm planning to use MacInTax. I don't need uncertainty in this area of my life.

Based on the elegance of MacInTax for 1986, and the fact that SoftView has been running through this drill since 1984, I have no qualms in endorsing its 1987 line sight unseen. I've watched demonstrations of the IBM PC version; as it's a pretty straightforward port, I'm sure it will be as valuable for the IBM PC crowd as it has been for the Macintosh world.

MacInTax and TaxView each sell for $119. Once you've bought the initial package, yearly updates are scheduled to go for $55 a pop. You can also spring for the TaxView Planner, a 5-year projection program that requires you to have the MacInTax/TaxView engine, for $79 for either machine. As noted, all forms the programs print out are approved by the IRS; just sign the things and send them on their way.

The only complaint I have is that neither program imports worksheets directly from Excel or Lotus 1-2-3. But given the power of these programs, I'm willing to live with that inconvenience.

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FrontRunner Development Corp.
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Van Nuys, CA 91411
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Printer Bridge

The best discovery of the month was the Grappler C/Mac/GS (Orange Micro, $99), the smartest cable I've encountered in a long time. It's designed to hook your Macintosh or Apple II to dot-matrix printers from the MS-DOS world, including those manufactured by Epson (FX-80, FX-100, FX Plus, RX, MX, LX, LQ, EX, and JX), Okidata (Microline 192, 193, and 292), Star (Gemini SG, SD, SR, and 10X), and C. Itoh (C-310XPR in Epson mode).

The Grappler is a serial/parallel converter with an intelligent ROM that converts Apple Imagewriter codes to those that drive your printer.

The computer end has a plug for an Apple II serial port (an 8-inch adapter cable is included for Mac users); it connects to your printer with a standard Centronics parallel interface. A small flat box (4 by 3 by 1 inches) at the printer end houses the Grappler's smarts. You run the cable between your machines, set four DIP switches in the box to tell the Grappler what kind of printer it's talking to, plug in a transformer unit, and you're in business.

I had a bit of a hassle getting the Grappler to drive my Microline 192. It seems that Okidata built two models of this printer, and I had the wrong one. The documentation didn't help on this, but after a few confused calls to Orange Micro, I got the printer running using one of the Epson settings. It was amazing watching the Okidata printer pretend it was an Imagewriter, printing Macintosh screen dumps and type fonts as if it had been made for the job.

The implications of this product are staggering. Mac and Apple II users are no longer trapped into buying an Imagewriter from Apple at double the price of some printers on the list. And anyone with both MS-DOS and Apple computers won't have to purchase a separate printer for each machine.

As I write this, the people at Orange Micro are busily polishing the ROM code to handle other 9-pin dot-matrix printers (like the IBM Proprinter), and they're waiting to see if they can convert the codes for the new Imagewriter LQ to drive 24-pin printers.

This is a great product.

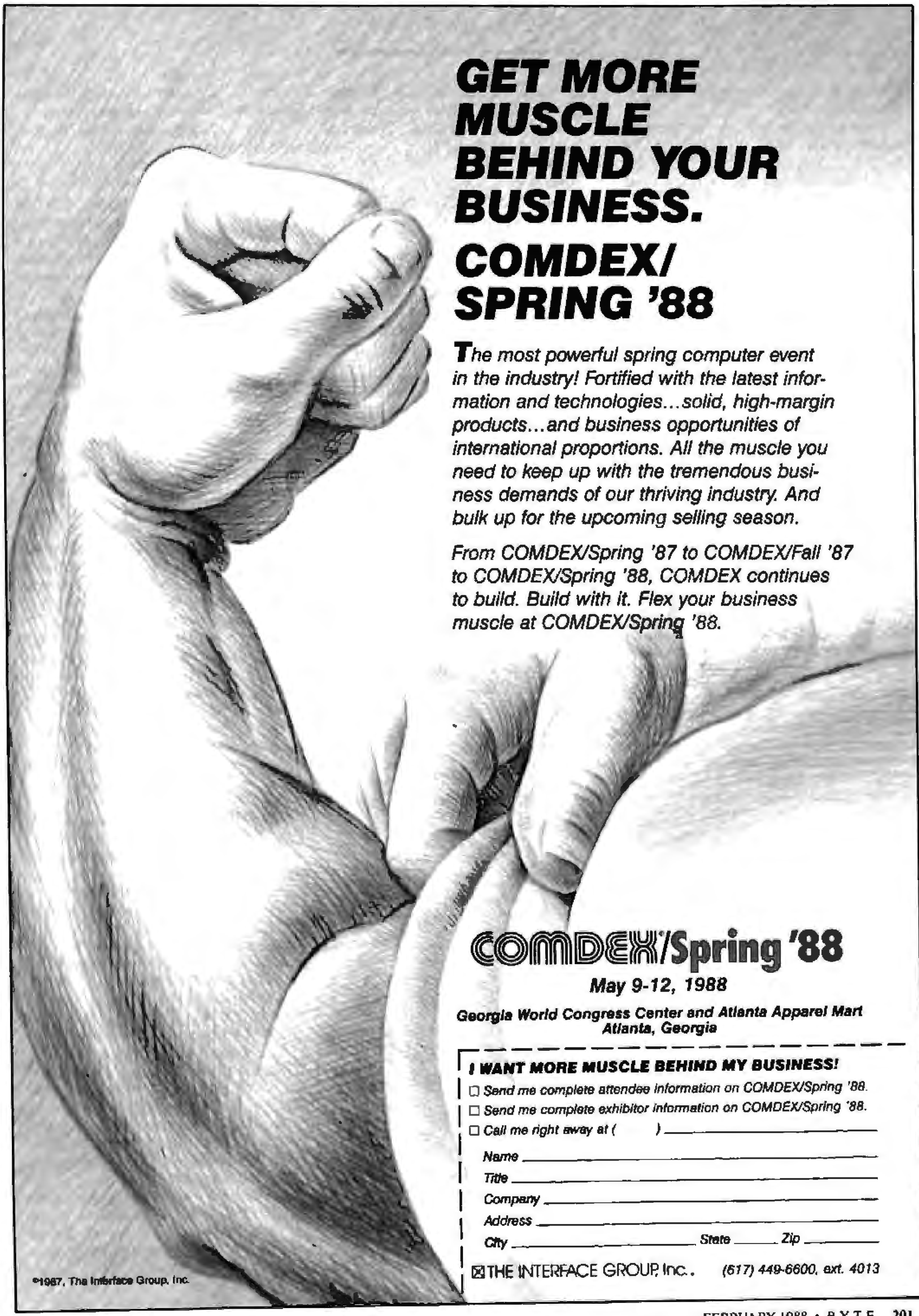
Shell Game 1: PC Side

As a rule, I don't much like shells for MS-DOS. I find they get in the way more than they help. And there are so many products on the market that I'm leery of writing about them for fear of being inundated with a deluge of programs that assume users need to be protected from the operating system rather than trained to utilize its strengths.

But I have been thoroughly charmed by TopDOS (FrontRunner Development, $69.95), a shell that makes real sense, even for people who know what they're doing with MS-DOS.

With my usual caveat that I can't guarantee the compatibility of any terminate-and-stay-resident program, I'd like to give big bonus points to TopDOS. It adds a raft of desirable features to DOS that, if you were to purchase them as separate

continued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utilities, would easily cost you triple the price of TopDOS.

Here's what you get: New commands, entered at the DOS prompt, including HISTORY (a command stack), MOVE (copy and delete from original directory), and WHEREIS (a blindingly fast file locator). Extensions to basic MS-DOS commands—COPY, DELETE, and MOVE can be performed with queries; DIR and DEL can be given multiple file specifications. A built-in full-screen text editor. A TREE display, in which you can tag files and directories for copy and/or delete operations. Keyboard macros and command aliases. Sorting. Context-sensitive help. Command completion (TopDOS will finish typing a command after a couple of keystrokes).

Furthermore, TopDOS fits in only 40K bytes of RAM, supports EGA displays and mice, and can handle hard disks of up to (ulp!) 1 gigabyte. The program signals that it's loaded by doubling the > character of the standard DOS prompt.

Though tree and help features make the program a useful crutch for novices, the rest of the package speeds things up for those who want to customize their environments into truly personal systems.

Gripes? Only that I wish I had discovered it sooner.

Shell Game 2: Mac Side

PowerStation (Software Supply, $59.95) is the first Finder replacement on the Mac I've seen that's worth using. Written by Steve Brecher, whose earlier WayStation became a popular public domain offering, PowerStation lets you create up to 16 pages with 27 item bars on each page. Each item is the name of a program or a desk accessory; click and launch the program. Documents created by any program can be attached to the appropriate bar, so you can jump directly to the file you want to be working in.

Access to the Apple Finder is always just one button click away, so you can use PowerStation as a secondary organizing tool as well as a total Finder replacement. It's for this type of use that I find PowerStation most effective.

As it's possible to put program names that live in different folders on the same page, you can create task-related screens in an entirely different arrangement from the way you've set up your hard disk. I've got applications located in folders organized by program type, and I group my documents by project name. That's fine most of the time, but when I'm starting something new and complex, I'll switch over to PowerStation, where I've installed programs by project type.

As an example, I keep SuperPaint in a folder with other art programs, PageMaker stays with layout tools, and Works resides with general applications. On my PowerStation screens, however, I've got a desktop-publishing page that shows all three programs at the same time. Since any program can be installed as many times as I need it, I've also constructed PowerStation pages for text handling, disk repair, communications, design, and so on. I don't use PowerStation all the time, but when I need it, it comes in mighty handy.

As I write this, PowerStation is being patched to run under Apple's new MultiFinder, where it will be a major blessing. With MultiFinder running, a 9-inch screen can get so crowded with windows that you can't even recognize that you're *in* the Finder, let alone start programs from it. PowerStation's neatly designed display will make identifying and launching software that much easier.

The price is reasonable, the program runs cleanly, and it's a delight if you aren't satisfied with the way the Finder does things. And it sure beats rolling your own with HyperCard. This is highly recommended. ■

Circle 229 on Reader Service Card

Intelligent statistics. Consider the alternatives.

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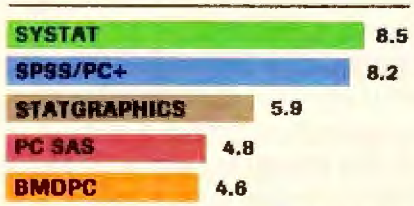
In its recent review of the five leading microcomputer statistics programs, *InfoWorld* concludes that Systat™ Version 3.0 is "unrivaled in performance", "tops in number crunching power" and "unfailingly accurate."

And *InfoWorld* doesn't stop here, but goes on to rank Systat as the Number One statistics package of the group.

In doing so, they aren't alone. Every published independent comparative review rates Systat at the top of the list.



Of the statistics packages reviewed by InfoWorld, *Systat rated highest, as it has in every published competitive review.*

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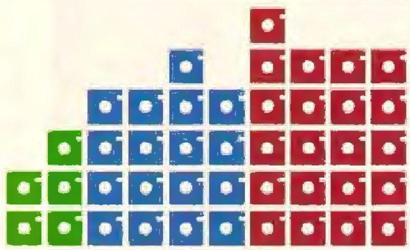

Although more comprehensive, Systat requires less than ½ the commands and has ½ the bulk of competitive programs. Compare its 5 disks to 17 for SPSS/PC+ and 21 for PC SAS!

Is ease of operation important? Systat operates on less than ½ the commands of its two largest competitors, with less than ½ the bulk. According to *InfoWorld*, "Systat's commands are terse, and a few keystrokes will do amazing things."

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Next to this, the alternatives to Systat don't look very bright.

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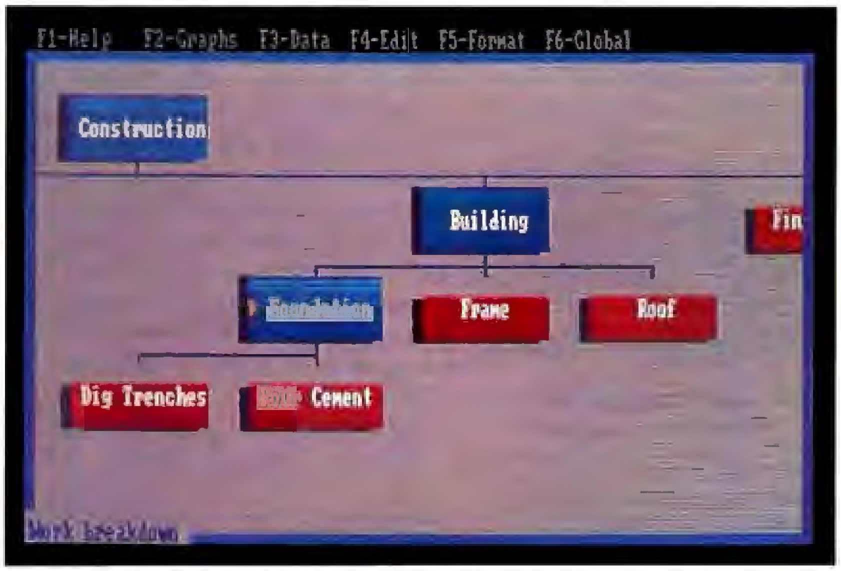

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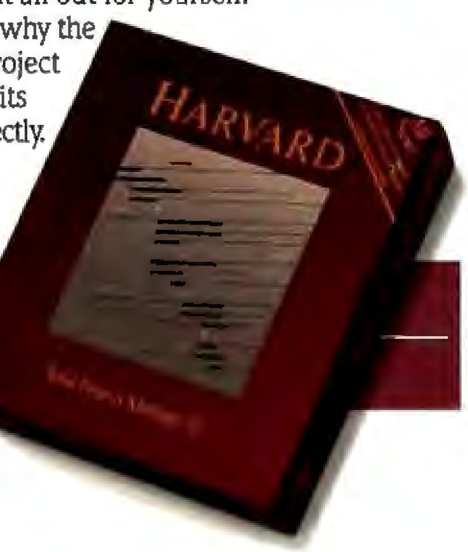

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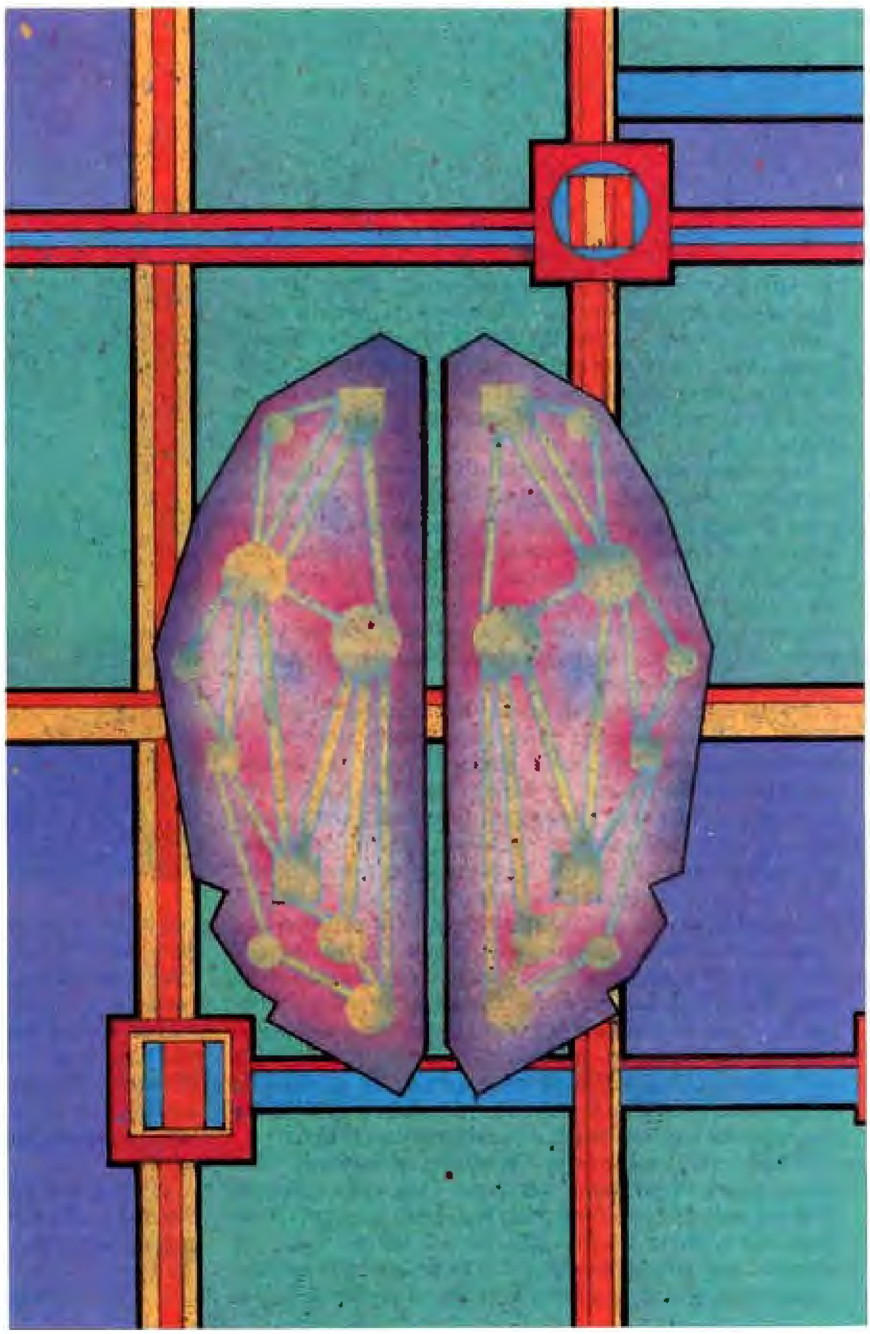
Lisp



Introduction

Lisp

Lisp has come to microcomputers—or, rather, micros have *finally* come to Lisp. When we last covered it, Lisp was only a distant vision in the eyes of most microcomputer users. Then, if you were lucky (and rich), you had an Apple II with a disk drive and 48K bytes of memory. Lisp, on the other hand, used megabytes of memory and considerable disk storage.

Now, things have changed in both directions: Some microcomputers have 16-bit processors and anywhere from 512K bytes to several megabytes of memory, and Lisp itself has grown to be simultaneously more powerful and (somewhat) less memory- and disk-intensive. The interest in artificial-intelligence technology has grown symbiotically with the memory-capacity growth of microcomputers and the availability of Lisp implementations for them big enough to solve "real-world" problems.

Just as Lisp has changed, so has our coverage of it. The 1979 Lisp issue contained mostly introductory articles, but we think that the 1988 BYTE reader is ready for articles going beyond the "what" of Lisp to the "why." Even for those of you who aren't, there are numerous good tutorial books on Lisp, and—at some level—you can still understand the underpinnings of Lisp that are discussed in these articles.

In "Lisp: A Language for Stratified Design," Harold Abelson and Gerald Jay Sussman pack a lot of important ideas into a relatively small article, in essence showing you how powerful Lisp is when it is used as it was designed to be used. Their first example shows how Lisp can solve a problem in a "building-blocks" way that can be changed easily to adapt to new conditions. The second example demonstrates the concept of *metalinguistic abstraction*, the process by which you can use Lisp to implement a custom programming language that you then use to solve the problem at hand.

William Clinger's article, "Semantics of Scheme," discusses issues of semantics that make Lisp more powerful than and very different from other high-level languages. One such idea is that of the *first-class object*, which means, for example, that a Lisp procedure can be defined and invoked without having a name, that it can be stored in a variable, and

that it can be passed to a procedure or returned by a procedure—all of which gives Lisp a power and a freedom that most other languages don't have.

David S. Touretzky's "How Lisp Has Changed" describes several important additions and evolutions to Lisp that have made it simultaneously more elegant and robust. His article directly addresses Common Lisp, a multifaceted standard that many vendors adhere to. The other articles use Scheme, an elegantly sparse dialect favored in the academic world.

We think that this is a very rich In Depth section of BYTE and that it offers considerable insight into the nature of this unusual language.

—David Betz, BIX Senior Editor
Gregg Williams, BYTE Senior Technical Editor

Illustration by Robert Tinney

Lisp: A Language for Stratified Design

Lisp's power comes from the ease with which you can make abstractions and build on them

Harold Abelson and Gerald Jay Sussman

JUST AS EVERYDAY thoughts are expressed in natural language, and formal deductions are expressed in mathematical language, methodological thoughts are expressed in programming languages. A programming language is a medium for communicating methods, not just a means for getting a computer to perform operations. Programs are written for people to read as much as they are written for machines to execute.

This article exhibits programs that illustrate the power of Lisp as a language for expressing the design and organization of computational systems. The examples are chosen to highlight the importance of *abstraction* in program design and to draw attention to the use of procedures to express abstractions.

Any programming language provides primitive components, means by which these can be combined, and means by which patterns of combination can be named and manipulated as if they were primitive. With appropriate abstractions to separate the specification of components from the details of their implementation, you can provide a library of standard components that can be freely interconnected, allowing great flexibility in design.

A language for design should not unnecessarily limit our ability to make abstractions. Most traditional programming languages, however, place arbitrary restrictions on procedural abstractions. Three common restrictions are (1) requiring that a procedure be named and then referred to by name, rather than stating its definition at the point of reference; (2) forbidding procedures to be returned as the values of other procedures; (3) forbidding procedures to be components of such data structures as records or arrays.

The well-publicized programming methodology of top-down, structured design produces systems that are organized as trees. Following this methodology, a system is designed as a predetermined combination of parts that have been carefully specified to be combined as determined. Each part is itself designed separately by this same process.

This methodology is flawed: If a system is to be robust, it must have more generality than is needed for the particular application. The means for combining the parts must allow for after-the-fact changes in the design plan as bugs are discovered and as requirements change. It must be easy to substitute parts for one another and to vary the arrangement by which parts are combined. This is necessary so that small changes in the problem to be solved can be accommodated by small changes in the design.

To this end, expert engineers stratify complex designs. Each level is constructed as a stylized combination of interchangeable parts regarded as primitive at that level. The parts constructed at each level are used as primitives at the next level. Each level of a stratified design can be thought of as a specialized language with a variety of primitives and means of combination appropriate to that level of detail.

For example, in electrical design, resistors and transistors are combined as analog circuits to make TTL, a language appropriate to digital circuits. TTL parts are in turn combined to build processors, bus structures, and memory systems appropriate to computer architecture. The real power of Lisp is that its unrestricted abstractions support the construction of new languages, greatly facilitating the strategy of stratified design.

The programs in this article are written in the Scheme dialect of Lisp. Scheme is an especially good vehicle for exhibiting the power of procedural abstractions because, to a greater extent than other Lisp dialects, Scheme does not distinguish between patterns that abstract over procedures and patterns that abstract over other kinds of data. For an introduction to the Scheme dialect, see the article by William Clinger on page 221.

[Editor's note: *STRATDES.SCM contains the Scheme source code for the examples in this article. It contains all the code needed to recreate the examples, including support code not given in this article. STRATDES.SCM is available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents. To "find" source code in the Listings areas on BIX and BYTEnet, search by article title, author, or issue date. Some archived files may contain numerous listings for a single article. A descrip-*

continued

Harold Abelson and Gerald Jay Sussman can be reached at the Department of Electrical Engineering and Computer Science, MIT, 545 Technology Square, Cambridge, MA 02139.

tion of the file also accompanies each entry.]

Expressing Abstractions as Procedures

Procedural abstractions can explain and clarify a process by letting us express it as an instance of a more general idea. Consider the simple square-root program of listing 1. The algorithm here is implemented in a straightforward way—the internal procedure `try` is iterated to repeatedly improve a guess for the square root until the guess is good enough.

Although the square-root implementation is straightforward, it does not express the underlying idea in generalizable form. It is not built out of components that can be easily isolated for use in solving other problems. A clearer way to formulate the algorithm is as a process of computing a *fixed point*: The square root of a radicand x is the number y such that $y = x/y$, or, in other words, y is a fixed point of the procedure

```
(lambda (y) (/ x y))
```

How do you find a fixed point of a function? In favorable cases, you can iterate the function until the result is close to the input. For example, during boring meetings many of us have noticed that we can find the fixed point of the cosine function by entering 1 on a pocket calculator and repeatedly pressing the cosine button. After a while, the calculated value converges to approximately .739085. You can capture that general idea as the `fixed-point` procedure shown in listing 2. Procedure `fixed-point`, given a one-argument procedure `f` and an initial value, keeps applying `f` until successive values are sufficiently close to each other.

You can attempt to find square roots by using the following definition of `sqrt`:

```
(define (sqrt x)
   (fixed-point (lambda (y) (/ x y))
                1))
```

[Editor's note: *The procedure* `(lambda (y) (/ x y))` *is an example of Lisp's ability to create a procedure without naming it—in this case, a procedure that performs* f(y) = x/y. *Here, this unnamed procedure serves as the first argument of the call to* `fixed-point`*; see listing 2.*]

Unfortunately, this doesn't work. Unlike the cosine function, applying the indicated procedure over and over does not converge to a fixed point, but rather alternates between the same two values, which are on opposite sides of the square root.

In situations like this, you can often force convergence by averaging. The `average-damp` procedure shown in listing 3 takes as its argument a procedure that computes a function f and returns as its result a procedure that computes a function with the same fixed point as f, but whose oscillations are damped out by averaging successive values. The new definition of `sqrt` shows how to use `average-damp` to express the square-root method as a process of finding the fixed point of an average-damped function.

The advantage of this formulation is that it decomposes the method into useful pieces—finding fixed points of general functions and using damping to encourage convergence. These ideas are formalized as procedural abstractions, identifiable units available to be used in other contexts.

Listing 1: *A first try at a square-root algorithm. Scheme is a block-structured language, incorporating the internal definitions and lexical scoping of the Algol family of languages into a modern Lisp dialect. This simple Scheme procedure computes the square root of its argument using the method of successive averaging attributed to Heron of Alexandria. For this and other Lisp listings, remember the formatting convention that items aligned vertically are members of the same list and are at the same logical level.*

```
(define (sqrt1 x)
  (define epsilon 1.0e-10)
  (define (good-enough? guess)
    (< (abs (- (square guess) x))
       epsilon))
  (define (improve guess)
    (average guess (/ x guess)))
  (define (try guess)
    (if (good-enough? guess)
        guess
        (try (improve guess))))
  (try 1))
```

Listing 2: *A simple fixed-point algorithm. This procedure implements the "boring meeting" method of finding a fixed point of a function. Note the use of this procedure to find a fixed point of cosine.*

```
(define (fixed-point f initial-value)
  (define epsilon 1.0e-10)
  (define (close-enough? v1 v2)
    (< (abs (- v1 v2)) epsilon))
  (define (loop value)
    (let ((next-value (f value)))
      (if (close-enough? value next-value)
          next-value
          (loop next-value))))
  (loop initial-value))

(fixed-point cos 1) --> .739085
```

Listing 3: *The procedure* `average-damp` *takes a procedure* `f` *as an argument and returns a procedure, the value of* `(lambda (x) ...)`*, as a value. This returned procedure takes one numeric argument and uses the procedure* `f` *to compute a value. Such general methods combine to allow a very clear description of Heron's algorithm.*

```
(define (average-damp f)
  (lambda (x)
    (average x (f x))))

(define (sqrt x)
  (fixed-point (average-damp (lambda (y) (/ x y)))
               1))
```

Stratified Design

Peter Henderson used stratified design in a beautiful analysis of the construction of the "Square Limit" woodcut of M. C. Escher. He created a sequence of languages that makes it easy to describe such images. There is a language of primitive pictures that are constructed from points and lines. Built on top of this is a language of geometric combination that describes how pictures are placed relative to one another to make compound pictures. Built on this is a language that abstracts common patterns of picture combination.

In Henderson's system, a picture is represented by a picture-drawing procedure that takes a rectangle and draws an image scaled to fit the rectangle. At the lowest level of description, a picture-drawing procedure can be generated beginning with a collection of geometric elements specified in terms of (x,y) coordinates with respect to the unit square ($0 \leq x \leq 1; 0 \leq y \leq 1$). Figure 1 shows two simple pictures, `diamond` and `leg`, each constructed from a set of line segments by the `primitive-picture` procedure. Besides segments, other picture elements appropriate to this level are circles with specified radii and centers, spline curves through designated points, and so on.

The `primitive-picture` procedure itself (listing 4) takes a list of line segments and returns the corresponding picture-drawing procedure. For any rectangle, the scaling and shifting required to transform geometric elements to fit the rectangle can be described by an affine transformation on points in the plane that maps the unit square to the rectangle. The `point-map` procedure shown in listing 5 takes a rectangle and returns an unnamed procedure that represents the appropriate transformation for that rectangle.

The next level of description in Henderson's system is a language of geometric combinators that place pictures beside or above one another and rotate pictures through multiples of 90 degrees. For instance, the `beside` combinator illustrated in figure 2 adjoins two pictures horizontally so that their widths are in a given ratio.

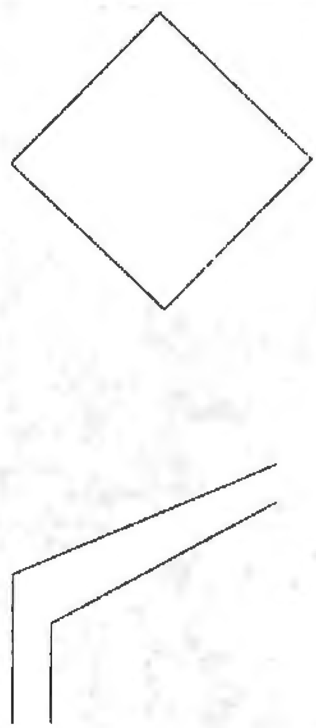
One important feature of Henderson's geometric combinators is that the set of all pictures is *closed* under combination: The `beside` of two pictures is itself a picture and can therefore be further combined with other pictures. In addition, combinators can be abstracted: You can express common patterns of picture combination as new picture combinators defined in terms of other combinators. For example, a `triangle` combination is

continued

A Note on Scheme

Programming languages should be designed not by piling feature on top of feature, but by removing the weaknesses and restrictions that make additional features appear necessary. The Scheme dialect of Lisp demonstrates that a very small number of rules for forming expressions, with no restrictions on how they are composed, suffices to form a practical and efficient programming language that is flexible enough to support most of the major programming paradigms in use today.

The article "Semantics of Scheme" by William Clinger on page 221 of this issue gives more information about Scheme; I've included the citations for Clinger's article and relevant books and articles in the "Further Reading" references at the end of this article.



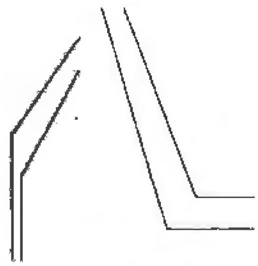
```
(define diamond
  (let ((v1 (vertex 0.5 0))
        (v2 (vertex 1 0.5))
        (v3 (vertex 0.5 1))
        (v4 (vertex 0 0.5)))
    (primitive-picture
      (list
        (segment v1 v2)
        (segment v2 v3)
        (segment v3 v4)
        (segment v4 v1)))))
```

```
(define leg
  (let ((v1 (vertex 0.125 0))
        (v2 (vertex 0.25 0))
        (v3 (vertex 1 0.75))
        (v4 (vertex 1 0.875))
        (v5 (vertex 0.25 0.333))
        (v6 (vertex 0.125 0.5)))
    (primitive-picture
      (list
        (segment v1 v6)
        (segment v6 v4)
        (segment v3 v5)
        (segment v5 v2)))))
```

Figure 1: *Examples of primitive pictures* `diamond` *and* `leg`. *At the lowest level of description in Henderson's language, pictures are specified as collections of individual geometric elements.*

Listing 4: *The* `primitive-picture` *procedure takes a list of segments and produces a picture. A segment is a structure from which you can extract a start point and an end point. Procedure* `drawline` *draws a line between two specified points. The Scheme procedure* `for-each` *takes a procedure and a list and applies the procedure consecutively to each item in the list. See listing 5 for an explanation of* `point-map`.

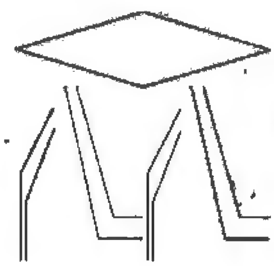
```
(define (primitive-picture segments)
  (lambda (rect)
    (for-each
     (lambda (segment)
       (drawline ((point-map rect) (start-point segment))
                 ((point-map rect) (end-point segment))))
     segments)))
```



```
(define (beside pict1 pict2 ratio)
  (lambda (rect)
    (pict1 (left-subrectangle rect ratio))
    (pict2 (right-subrectangle rect ratio))))

(define legs (beside leg (rotate90 leg) 0.3))
```

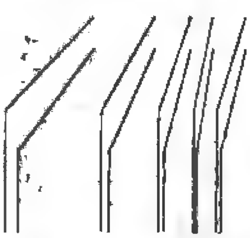
Figure 2: *Working at a higher level of abstraction. Here is a compound picture formed from the primitive element* `leg`*. The procedure* `beside` *takes two pictures and a ratio and returns the procedure that takes a rectangle as an argument, splits it according to the ratio into right and left subrectangles, and draws one picture in each part; here, the left subrectangle is 0.3 of the width of the total rectangle. The picture language includes this and other geometric combinators for adjoining pictures horizontally and vertically and for rotating pictures by 90 degrees.*



```
(define (triangle pict1 pict2 ratio)
  (above pict1
         (beside pict2 pict2 0.5)
         ratio))

(define animal (triangle diamond legs 0.3))
```

Figure 3: *The* `triangle` *combinator places one picture above two copies of another. You can use* `triangle` *to combine* `diamond` *and* `legs`.



```
(define (right-push pict n ratio)
  (if (= n 0)
      pict
      (beside pict
              (right-push pict (- n 1) ratio)
              ratio)))

(right-push leg 4 0.4)
```

Figure 4: *The recursively defined combinator* `right-push` *repeatedly adjoins* `n` *copies of a picture, scaled by a given ratio. Here you see the result of adjoining* `leg` *to itself 4 times.*

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When you design a system that incorporates a custom application language, you must address metalinguistic issues as well as linguistic issues.

formed by placing one picture above two copies of another, as shown in figure 3.

Since combinators are expressed procedurally, all the power of Lisp is at your disposal in defining complex combinators. Figure 4 shows the recursive combinator `right-push`, which adjoins *n* scaled-down copies of a picture. The combinator language derives its power from the closure and abstraction properties of the combinators. That is why it can describe seemingly complex figures using only a few simple ideas.

The combinators themselves are manipulated at a third linguistic level that describes common patterns of combining picture combinators. Just as the square-root algorithm above is made clearer by expressing it as a fixed-point computation, `right-push` can be re-expressed as an instance of a general pattern of "pushing"—repeatedly applying a combinator:

```
(define right-push (push beside))
```

Figure 5 shows how to define push as a procedure that transforms combinators to combinators. Having isolated the `push` abstraction, you can apply it to other combinators such as `triangle` and use the resulting derived combinators to produce simple, stratified descriptions of complex pictures, such as the one given in figure 5.

The stratified description of the picture in figure 5 is flexible. You can vary the pieces at any level: You can change the location of a point in the primitive picture `leg`, replace the compound picture `animal` by some other basic repeated unit, replace `triangle` by some other combinator to be pushed, or replace push by some other transformation of combinators.

Listing 5: *The* `point-map` *procedure. A rectangle is a data structure from which you can select vectors representing the bottom and left edges of the rectangle (i.e., the vectors that run from the origin of the rectangle to the lower right corner and to the upper left corner) and the vector that runs from the origin of the coordinate space to the origin of the rectangle. Scheme, as a dialect of Lisp, provides list operations from which you can construct compound data objects, such as rectangles and vectors, together with operations on compound data objects, such as vector addition and scaling.* `Point-map` *produces a transformation that, for a given rectangle* `rect`*, maps the unit square onto* `rect`*. The transformed image of a point* (x,y) *within the unit square is obtained by scaling the bottom edge by* x*, and the left edge by* y*, and summing these together with the origin vector.*

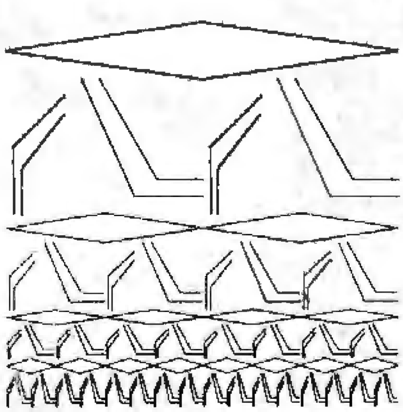
```
(define (point-map rect)
 (lambda (point)
   (+vect (scale-vector (x-coordinate point) (bottom-edge rect))
          (scale-vector (y-coordinate point) (left-edge rect))
          (origin rect))))
```

Metalinguistic Abstractions

Procedural abstractions are a source of power in creating stratified designs—you build structures by composing procedures, you abstract common patterns of usage, and you build upon this framework. But for some problems, the appropriate means of combination may be awkward to express as compositions of procedures; towers of abstractions may not suffice.

The natural programming style for Lisp is functional: The structural units are procedures that implement single-valued mathematical functions. Within this style, Lisp accommodates object-oriented programming and imperative programming.

Traditional algorithmic languages such as Pascal, C, and FORTRAN are more naturally imperative: The statements and the subroutines we build modify the memory of an abstract machine. In a logic programming language such as Pro-



```
(define (push combiner)
  (lambda (pict n ratio)
    (define (basic-combination p)
    (combiner pict p ratio))
   ((repeated-application n basic-combination) pict)))

(define (repeated-application n operator)
  (if (= n 0)
      identity-operator
      (compose operator
               (repeated-application (- n 1)
                                     operator))))

(define (compose f g)
  (lambda (x) (f (g x))))

(define identity-operator (lambda (x) x))

((push triangle) animal 3 0.5)
```

Figure 5: *A still higher level of abstraction. The procedure* push *is a higher-order combinator that transforms combinators to more elaborate combinators. The helper procedure* `repeated-application` *takes a positive integer* n *and a procedure* p *and returns the procedure that applies* p n *times.*

Table 1: *Examples of the algebraic-simplification rules. Here are some algebraic-simplification rules expressed in a reduction-rule language, together with examples of their use. Note that each rule is expressed as a list with three elements—the pattern, the extra conditions (none if there are none), and the skeleton of the simplified result. Segment variables, of the form* (?? n), *can match any sequence of zero or more elements, which are substituted for the pattern* (:: n) *into the corresponding skeleton. See the text for more details.*

```
Rule 1     ( (- (? x) (? y))                 ;pattern
             none                            ;extra condition
             (+ (: x) (* -1 (: y))) )        ;skeleton

Example.   (- a b) --> (+ a (* -1 b))

Rule 2     ( (* (?? a) (+ (? b) (?? c)) (?? d))
             none
             (+ (* (:: a) (: b) (:: d)) (* (:: a) (+ (:: c)) (:: d))) )

Example:   (* w x (+ p q r) z) -->  (+ (* w x p z) (* w x (+ q r) z))

Rule 3     ( (+ (? c1 number?) (? c2 number?) (?? s3))
             none
             (+ (: (+ c1 c2)) (:: s3)) )

Example.   (+ 3 4 x y) --> (+ 7 x y)

Rule 4.    ( (* (?? s1) (? f1) (?? s2) (? f2) (?? s3))    ;pattern
             (same-base? f1 f2)                           ;extra condition
             (* (^ (: (base f1)) (: (+ (exponent f1) (exponent f2))))
                (:: s1) (:: s2) (:: s3)))                 ;skeleton

Example    (* a (+ b c) (^ x 3) y (^ x 4) (^ z 2))
             --> (* (^ x 7) a (+ b c) y (^ z 2))
```

log, the natural structural units are (multivalued) relations rather than (single-valued) functions or imperative operations.

In simulation or artificial-intelligence applications, it is natural to describe processes in event-driven style by specifying collections of rules that correspond to conditions or goals. Each of these programming paradigms is legitimate, but no single paradigm is sufficient; large systems typically have some parts that are naturally described using one style and other parts that are more naturally expressed in other ways.

Part of the wonder of computation is that you have the freedom to change the framework by which the descriptions of processes are combined. If you can precisely describe a system in *any* well-defined notation, then you can build an interpreter to execute programs expressed in the new notation, or you can build a compiler to translate programs expressed in the new notation into any other programming language.

When you design a system that incorporates a custom application language, you must address *metalinguistic* issues as well as linguistic issues; that is, you must consider not only how to describe a process, but also how to describe the language in which the process is to be described. You must view your programs from two perspectives. From the perspective of the interpreter or compiler, an applications program is merely data, and the interpreter or compiler operates on that data without reference to what the program is intended to express. From the perspective of the user programming in the application language, you view that same data as a program with meaning in the domain of the application.

Interpreters and compilers are just programs, but they are special programs. We will call the language in which the interpreter is implemented or to which the compiler translates the *underlying language*. An applications program to be interpreted or compiled is not a composition of abstractions in the underlying language. Rather, it is a composition of abstractions in another language, with primitive operations and means of combination that need not appear in the underlying language. Thus, this linguistic shift transcends the limits of abstraction.

continued

Rule	(- (? x)(? y))	→	(+ (: x) (* -1 (:y)))
Example	(- a b)	→	(+ a (* -1 b))

Figure 6: *Explaining an algebraic-simplification rule. A symbol of the form* (? n) *represents a* pattern variable *that must match a single element. If the rule is carried out, this same element will replace the corresponding* (: n), *as shown in the example. This rule looks for any list of a minus sign followed by two other elements and replaces it with the list* (+ el1 (* -1 el2)), *where* el1 *and* el2 *are the second and third elements in the original list. See table 1 and the text for details.*

A linguistic approach to design is an essential aspect not only of programming but of engineering design in general.

You can implement interpreters and compilers in any programming language, but Lisp's facility with symbolic data provides unusually good support for developing such subsystems. The Lisp community regards metalinguistic abstraction as a standard programming technique. Almost every large Lisp program includes interpreters and compilers for several specialized languages, each tailored to a specific part of the application problem.

A Rule Language

Consider the problem of simplifying algebraic expressions. For example, it should be possible to simplify

$$(x + \sin(xy))(\sin(xy) - x) + \cos(xy)\cos(yx)$$

to $1 - x^2$. The simplification process can be captured as a collection of rules and a strategy for applying them. The rules embody the commutative and distributive laws, various trigonometric identities, and so on. Each rule describes how to reduce expressions of a certain form to simpler equivalent expressions. Given an expression, you find an applicable rule, transform the expression accordingly, and then attempt to simplify the transformed expression. The process continues until you reach an expression to which no rules apply.

Table 1 shows some algebraic-simplification rules written in a language that was designed specifically for implementing simplifiers; figure 6 explains the notation in more detail. A rule in the language is a list with three parts: a *pattern*, some extra conditions, and a *skeleton*. The pattern specifies the class of expressions to which the rule is applicable. A rule is applicable to an expression if the rule pattern matches a subexpression and if the extra conditions are satisfied. The result of a rule application is the original expression with the matched subexpression replaced by the instantiated rule skeleton. The instantiated skeleton is formed by substituting values provided by the match in place of the indicated skeleton variables.

In this algebraic-simplification language, a symbol of the form `(? n)` represents a *pattern variable* that must match a single element (in this example, `(? x)` matches the element `a`). If the rule is carried out, this same element will replace the corresponding `(: n)` in the instantiated skeleton, as shown in the example in rule 1 of `(- a b)` simplifying to `(+ a (* -1 b))`. Segment variables, of the form `(?? n)`, can match any sequence of zero or more elements, which are substituted for the pattern `(:: n)` into the corresponding skeleton.

You can also use *pattern-variable predicates* to restrict the range of values of an element or segment, as shown in rule 3. Here `c1` and `c2` must satisfy the `number?` predicate. In general, a pattern-variable predicate can be any Lisp procedure. Rule 4 uses an extra condition to specify that factors `f1` and `f2` must have the same base if their exponents are to be combined. Observe that instantiating the skeletons for rules 3 and 4 requires more than just substitution—embedded Lisp expressions must be evaluated. The single colon in the skeleton of rule 3 is taken to mean "the value of," so that `(: (+ 3 4))` evaluates to 7.

In all, about 30 rules, such as the ones in table 1, suffice to produce an algebraic simplifier that operates on expressions represented using Lisp-style prefix notation. Having created the rule language, you can apply it to other problems as well by specifying other sets of rules. For example, you could do algebraic simplification using some other syntax for algebraic expressions, or you could build a peep-

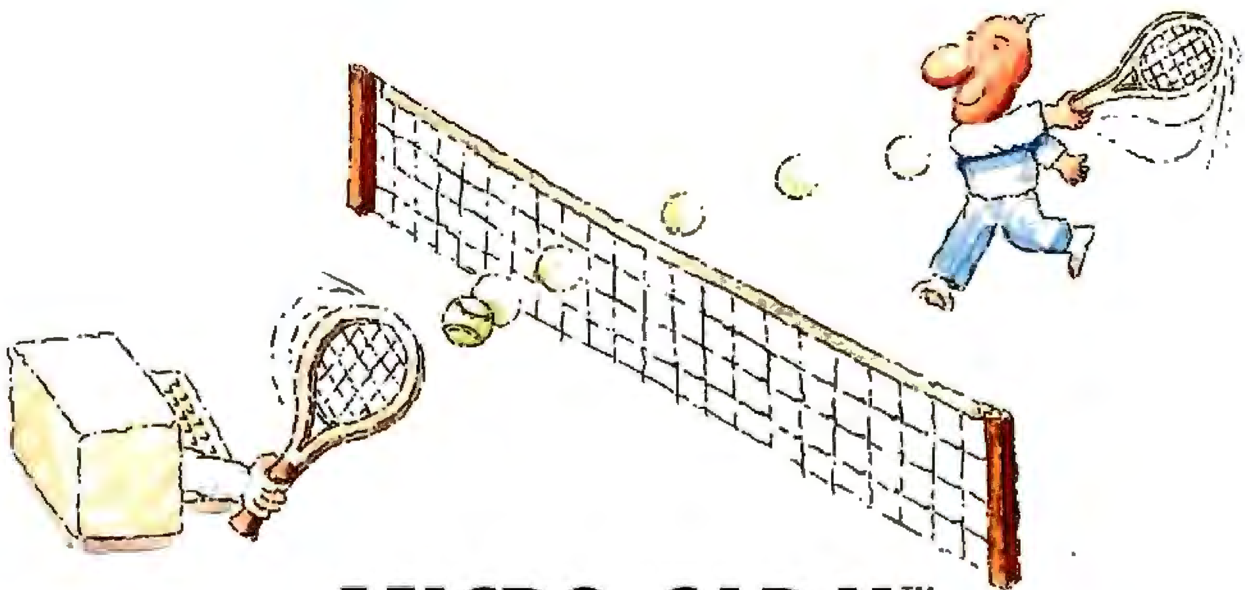
continued

Listing 6: *Given a set of rules,* `make-simplifier` *produces a procedure that applies these rules to expressions. It recursively simplifies every subexpression of a compound expression and simplifies the resulting combination of the simplified parts. The procedure iterates the simplification until the expression remains unchanged.*

```
(define (make-simplifier the-rules)
  (define (simplify-exp exp)
    (let ((result
           (try-rules (if (compound? exp)
                          (map simplify-exp exp)
                          exp)
                      the-rules)))
      (if (equal? result exp)
          result
          (simplify-exp result))))
  simplify-exp)
```

Listing 7: *The procedure* `try-rules` *performs a sequential scan through the rules, using a pattern matcher to check whether a rule is applicable. It calls* `match`, *which has five arguments—a pattern, an expression, a dictionary of bindings for pattern variables, a procedure to be executed if the match fails, and a procedure to be executed if the match succeeds. If the match is successful,* `try-rules` *checks that the values in the dictionary satisfy the rule's extra conditions. If they do, the dictionary is used to instantiate the skeleton part of the rule. This is returned as the result of the rule application. If the dictionary fails the extra condition test,* `try-rules` *continues just as if the match had failed, by calling the* `fail` *procedure.*

```
(define (try-rules exp the-rules)
 (define (scan rules)
   (if (null? rules)
     exp
     (match (pattern (car rules)) exp (make-empty-dictionary)
            ;; procedure to call if the match fails
            (lambda () (scan (cdr rules)))
            ;; procedure to call if the match succeeds
            (lambda (dict fail)
              (if (check-predicate (rule-condition (car rules))
                                   dict)
                  (instantiate (skeleton (car rules)) dict)
                  (fail))))))
(scan the-rules))
```



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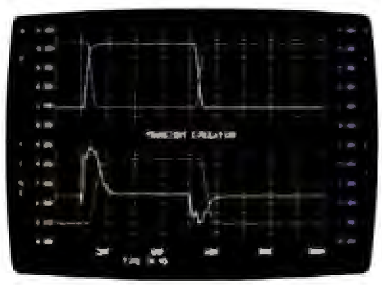

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hole optimizer for a compiler by specifying a collection of rules that reduce specified sequences of computer instructions to more efficient, equivalent sequences.

The Rule Interpreter

Programming a simplifier in the rule language lets us focus on the rules themselves, without becoming distracted by concerns about the strategy and mechanism by which rules are applied. These issues are faced by the rule interpreter.

Given a list of rules, `make-simplifier`, shown in listing 6, returns a simplification procedure that applies these rules. This procedure embodies a rule-application strategy whereby rules are repeatedly applied until the expression is unchanged. Using this strategy with a set of arbitrary rules can be dangerous—the rule application process may not terminate, or the result of applying the rules may not be well-defined. With this strategy, you must be careful to propose rules that yield a *reduction* process—one that will eventually terminate with a canonical form.

The mechanism of rule application is implemented by `try-rules`, which is shown in listing 7. The pattern-matcher used by `try-rules` (see listings 8, 9, and 10) is written in *continuation-passing style*. In this style, a procedure is passed continuation procedures that are to be called when the procedure is done. Continuation-passing style can be used to implement many sophisticated program control structures. The matcher exploits continuation style to implement the backtracking required to handle segment variables.

The difficulty with segment variables is that they allow a pattern to match a given data item in more than one way. For example, the pattern

`((?? x) (?? y) (?? x) (?? z))`

can be matched against the expression

`(1 2 3 1 2 3 1 2 3)`

to give the dictionary

x : (1)
y : (2 3)
z : (2 3 1 2 3)

or the dictionary

x : (1 2)
y : (3)
z : (3 1 2 3)

or the dictionary

continued

Listing 8: *The* `match` *implements a recursive comparison that proceeds by case analysis. Pattern variables are of two classes, elements and segments, handled by* `element-match` *and* `segment-match`*, respectively. If the pattern and the datum are both general compound expressions,* `match` *calls itself recursively to match the first element of the pattern against the first element of the datum. The* `fail` *continuation for this submatch is the original* `fail` *continuation. If the submatch succeeds, the rest* (`cdr`) *of the pattern is matched against the rest of the datum, using the dictionary produced by the submatch and the continuations specified for the original match.*

```
(define (match pat dat dict fail succeed)
  (cond ((eq? pat dat)
         (succeed dict fail))
        ((arbitrary-element? pat)
         (element-match pat dat dict fail succeed))
        ((constant? pat)
         (if (same-constant? pat dat) (succeed dict fail) (fail)))
        ((start-arbitrary-segment? pat)
         (segment-match pat dat dict fail succeed))
        ((constant? dat) (fail))
        (else
         (match (car pat) (car dat) dict
                fail
                (lambda (dict fail)
                  (match (cdr pat) (cdr dat) dict
                         fail
                         succeed))))))
```

Listing 9: *The* `element-match` *procedure takes a pattern variable, a datum to match, a dictionary, and* `fail` *and* `succeed` *continuations. When there is already an entry for the variable in the dictionary, the match succeeds if the value in the entry is the same as the datum to be matched. Otherwise, the original dictionary is extended by adding a binding of the pattern variable name to the datum. The extended dictionary is passed to the* `succeed` *continuation.*

```
(define (element-match pat dat dict fail succeed)
  (let ((vname (var-name pat)) (p (var-restriction pat)))
    (let ((v (lookup vname dict)))
      (if (entry-exists? v)
          (let ((val (element-in v)))
            (if (and (equal? val dat)
                     (apply-restriction p val))
                (succeed dict fail)
                (fail)))
          (if (apply-restriction p dat)
              (succeed (extend-dictionary vname dat dict) fail)
              (fail))))))
```

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Listing 10: *The* segment-match *procedure implements backtracking via a failure continuation that tries successively longer segments. The utility procedure* after-initial-segment *returns the rest of the datum after a given initial segment, or notes that the initial segment of the datum does not match the desired segment.*

```
(define (segment-match pat dat dict fail succeed)
  (let ((vname (var-name (car pat))) (p (var-restriction (car pat))))
    (let ((v (lookup vname dict)))
      (if (entry-exists? v)
          (let ((val (element-in v)))
            (if (restrict-segment p val)
                (let ((rest (after-initial-segment val dat)))
                  (if (not (eq? rest 'no-initial-segment))
                      (match (cdr pat) rest dict fail succeed)
                      (fail)))
                (fail)))
          (let ()                          ;to permit internal definition
            (define (try-segment rest)
              (define (try-longer-segment)
                (if (null? rest) (fail) (try-segment (cdr rest))))
              (if (restrict-segment p (make-segment dat rest))
                  (match (cdr pat)
                         rest
                         (extend-dictionary vname
                                            (make-segment dat rest)
                                            dict)
                         try-longer-segment
                         succeed)
                  (try-longer-segment)))
            (try-segment dat))))))
```

```
x : (1 2 3)
y : ()
z : (1 2 3)
```

or 13 other possible dictionaries. (See the caption of table 1 for an explanation of the ?? notation.)

One way to handle such multiple matches is to design the matcher so that it returns a list of all possible dictionaries that could complete the match. But this would be very inefficient—for a complex pattern there could easily be thousands of possibilities, and there is no need to generate them all.

An alternative idea is to have the matcher generate a single dictionary to be used by the rule interpreter, *together with* a way to go back and generate more possibilities if the first one proves to be unsuitable—for example, if the values in the dictionary turn out not to satisfy the rule predicate. The strategy of returning to a previous choice point in a program to try more possibilities is called *backtracking*. While there are many ways to implement backtracking, continuation passing fills the need nicely, because the "place to go back to" can be embedded in the failure continuation.

Listing 10 shows the procedure segment-match, which uses continuations to implement backtracking in this way. Where there is no value for the pattern variable already in the dictionary, the matcher is free to bind the segment variable to *any* initial segment of the datum. The choice is made using the internal procedure try-segment, whose argument is the rest of the data after the segment to be tried. The success continuation for this choice is the same as for the original call. The failure continuation reruns try-segment, choosing a longer initial segment. Successive failures will try longer and longer segments until either the match succeeds or the data runs out and the original fail continuation is invoked.

Conclusion

People who first learn about Lisp often want to know for what particular programming problems Lisp is "the right language." The truth is that Lisp is not the right language for any particular problem. Rather, Lisp encourages you to attack a new problem by implementing new languages that are tailored to the particular problem.

Such a language might embody an alternative computational paradigm, as in the rule language discussed above. Or it might be a collection of procedures that implement new primitives, means of combination, and means of abstraction embedded within Lisp, as in the Henderson drawing language. A linguistic approach to design is an essential aspect not only of programming but of engineering design in general. Perhaps that is why Lisp, although the second-oldest computer language in widespread use today (only FORTRAN is older), still seems new and adaptable and continues to accommodate current ideas about programming methodology. ■

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Semantics of Scheme

Much of Scheme's elegance and power comes from a minimal but conceptually rich programming model

William Clinger

who pays any attention to the syntax of things will never wholly kiss you...
—e. e. cummings

PROGRAMMING LANGUAGES ARE artificial languages with syntax (grammar) and semantics (meaning). Both syntax and semantics can be specified precisely using formal mathematical notation. Semantics is more important than syntax, but while most programmers today understand syntax and can read and write formal grammars that express syntax, most have only a vague understanding of programming language semantics and few can read formal semantics.

The fact that programmers can understand code without knowing what computer it runs on proves that programs have meanings independent of their implementations. What might these be? The meaning of a complete program might be a function from inputs to outputs. This meaning is built up from the meanings of the statements and other phrases that make up the program. For example, the meaning of a statement is typically a transformation from one program state to another. As the statements combine according to the syntax, so do their meanings compose to form new meanings, ultimately yielding the meaning of the program.

A program's meaning is defined not in terms of a sequence of states, but in terms of state transformations that compose to form new transformations. This makes optimizing compilers possible. An optimizing compiler can replace a compound statement with any other statement that computes the same transformation. The new statement does not have to step through the same sequence of states as the original, so long as the optimized code means the same transformation as the original.

Language designers bear a special responsibility to think carefully about the semantics of languages they design. If they do not, the relationship between the structure of a program and its meaning may be too complicated for programmers to understand easily, even if the computer can understand it. Language designers should remember that programming languages are used less to communicate with machines than with other programmers.

This article introduces many of the concepts used in semantics while describing, informally, the semantics of Scheme, a modern dialect of Lisp that is especially well suited to small computers. Scheme is, for several reasons, an excellent medium for learning about semantics. It is essentially a superset of the formal language most often used to specify semantics. The Scheme standard includes formal syntax and semantics for most of the language (see reference 1). Furthermore, Scheme itself benefits from the simplicity and precision that formal semantics can bring to informal concepts like variables and procedures.

Syntax

The syntax of Scheme is very simple and regular. Programs consist of variable and procedure definitions mixed with top-level expressions that perform initialization and initiate execution of the program. There are only six basic kinds of expressions whose semantics must be explained: constants, variables, assignments, procedure calls, conditionals, and lambda expressions. All but lambda expressions are common in conventional programming languages. Scheme derives astonishing power from such a small core language because its primitive expressions have extremely simple semantics, which are free of the artificial restrictions that complicate and cripple conventional languages.

The value of a constant is a Scheme object. Except for numbers, strings, characters, and the Boolean constants `#t` and `#f`, constants must begin with a quotation mark. Symbols, for example, are like enumerated values in Pascal or C but are more useful in Scheme (and Lisp generally) because they can be read and written using the standard input and output procedures. The symbol `green` can be written as the constant `'green`. The quotation mark identifies what follows as a symbol, not a variable.

Ordered lists form another data type that often appears in constants. For example, the empty list `()` can be written as the constant `'()`, and the list `(red green blue)` can be written as the con-

continued

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Some Notes on Scheme

Gregg Williams, Senior Technical Editor

The Scheme programming language was introduced by Gerald Jay Sussman and Guy L. Steele Jr. in 1975 as a distillation of Lisp into a simple, elegant form suitable for study of and experimentation with the language itself. Though there's more to the language than I can describe here, the following notes will help the reader unacquainted with Lisp and Scheme follow the programs in this article.

• **What versus how**: Over the years, I've read and studied Lisp books seriously but couldn't get "into" the language. One reason for this is that many books tell you *what* a particular version of Lisp does but not *how* you should use it to solve a problem. The one book that has single-handedly broken this internal barrier is *The Little Lisper, Trade Edition* (see reference 7). It is a series of question-answer pairs—you read the questions and try to answer them; in the process, you write quite a few Lisp programs and build up an experiential understanding of the language. I highly recommend it as a way to understand the recursive, mathematical style of thinking for which Lisp is optimized.

• **Reading Lisp code**: Yes, you say you get lost in a forest of parentheses when you try to read a Lisp program; so do I. But I've had an easier time of it once someone pointed out that Lisp programs are often formatted so that elements at the same level are aligned vertically. For example, it's easy to see the structure of the following `if` statement:

```
(if cond expr1 expr2)
```

but much harder to see it here:

```
(if (null? x)
    n
    (length2 (cdr x) (+ n 1)))
```

until you see the alignment of the parenthesis before `null?`, the `n`, and the parenthesis before `length2` as a visual cue that you have three items, all arguments to the `if` that precedes them.

• **Some fundamental Scheme constructs**: The `if` syntactic form in Scheme looks like this:

```
(if test-expr true-expr false-
 expr)
```

and is equivalent to the following structured pseudocode:

```
if test-expr is true then
   evaluate true-expr
  else
   evaluate false-expr
end if
```

The `cond` syntactic form is like a set of nested `if` statements in other languages:

```
(cond
    [test-expr1 expr1]
    [test-expr2 expr2]
     ...
    [else exprn])
```

Its meaning is as follows:

```
if test-expr1 is true then
      evaluate expr1
    else
      if test-expr2 is true then
        evaluate expr2
      else
         ...
         else evaluate exprn
        endif
      ...
    endif
endif
```

Some versions of `cond` do not allow square brackets to enclose each test/

stant `'(red green blue)`.

Variables name objects. As in most programming languages, the naming rules are subtle, so I will describe them later. The spelling rules are merely unusual, as these six variables illustrate: `x15`, `x-15`, `+`, `-`, `null?`, and `list->vector`.

Another unusual but more important aspect of Scheme variables is that they name procedures as well as other objects. Thus, `+` names the procedure that adds numbers, and `null?` names the procedure that returns #t if its argument is the empty list.

Unlike the familiar *f(x,y)* notation for procedure calls, Scheme and other dialects of Lisp move the procedure inside the parentheses and use spaces as separators instead of commas, as in `(f x y)`. All procedure calls use this syntax. For example, `(+ 3 4)` returns 7. The general form of a procedure call in Scheme is `(E0 E1 ...)`, where E0, E1, and ... are expressions.

The procedure expression E0 is usually a variable (as in `(foo a b c)`, where `foo` has been `define`d as a procedure), but it can be a procedure call or any other kind of expression. It is not unusual for the expression E0 itself to be a procedure call that returns a procedure. Scheme will then use the expressions that follow E0 to compute the arguments to that procedure. This is a convenient way for programs to delay until run-time the decision of which procedure should be called on those arguments, and is commonly used in object-oriented programming.

Other kinds of expressions look like procedure calls but are distinguished by the appearance of a keyword where the procedure expression E0 would go. Keywords look like variables, so Scheme programmers must simply remember the 15 keywords used in standard Scheme.

The form of an assignment is `(set! V E)` (pronounced "set-bang v e"), where V is a variable and E is an expression. Assignments are not used much in Scheme, because binding (described later) is easier to think about in most cases.

Conditional expressions are written as `(if E0 E1 E2)` where E0, E1, and E2 are expressions. For example, the value of `(if (> x 0) x 0)` is the value of x if x is positive and is 0 otherwise. Conditional expressions were invented for Algol 60 by John McCarthy, the inventor of Lisp.

Listing 1: *A procedure that returns the length of a list. The procedure* `length` *takes one argument,* x, *recursively calls itself with a list that is one element shorter than its argument, and adds 1 to the answer.*

```
(define (length x)
  (if (null? x)
      0
      (+ (length (cdr x)) 1)))
```

expression pair; they use parentheses.

The `let` syntactic form, written as

```
(let ((id1 val1) ... (idM valM))
 expr1 ... exprN)
```

gives each `id` identifier its corresponding `val` value, then evaluates all the `expr` expressions in order. The values `val1` through `valM` are computed in an undetermined order. Finally, the `lambda` syntactic form, used to define an unnamed procedure, has the form

```
(lambda (arg1 ... argM) expr1 ...
 exprN)
```

The `lambda` form returns a function that takes *M* arguments and causes expressions `expr1` through `exprN` to execute in sequence. Note, however, that the procedure has no name; you can give it a name by enclosing it with

```
(define procname ... )
```

This explains why many Scheme procedures begin with

```
(define procname
    (lambda (x y z) ...))
```

and are called with

```
(procname xval yval zval)
```

Though Pascal and Modula-2 dropped conditional expressions, they can be written in C as `E0?E1:E2`.

A lambda expression `(lambda (V1 ...) E)` has as its value a procedure whose formal arguments are `(V1 ...)` and whose body is the expression `E`. Scheme owes much of its power to this ability to create procedures dynamically, as shown by Abelson and Sussman in their article "Lisp: A Language for Stratified Design" on page 207.

The `(define (length x) ...)` syntax used in listing 1 to define a procedure is equivalent to `(define length (lambda (x) ...))`. Hence, `length` is a procedure of one argument, x, which should be a list. If x is the empty list, then its length is 0. Otherwise its length is 1 greater than the length of `(cdr x)`, which is the list beginning with the second element of x. (The `car` procedure, which takes a list and returns its first argument, and the `cdr` procedure, which takes a list and returns the list beginning with its second element, derive their names from addressing modes that were used in the very first implementation of Lisp nearly 30 years ago.)

Semantic Issues in Language Design

Knowing the syntax of Scheme doesn't tell you very much about it. You might observe from its lack of statements that Scheme is an expression-oriented language, in contrast to conventional statement-oriented languages. Statement-oriented languages try to distinguish program fragments that behave like mathematical expressions (*expressions*) from those that change the state of the program (*statements*). This is a worthy goal, but hardly any languages achieve it because a side effect (change of program state) can usually be slipped into a function body. Indeed, most languages supply standard functions (e.g., a random-number function) that have side effects.

Scheme avoids this hypocrisy by dropping the distinction between expressions and statements, while doing more than most statement-oriented languages to encourage a style of programming in which expressions really do behave like mathematical expressions. That Scheme procedures are called procedures rather than functions is, however, a reminder that some of them have side effects.

From the lack of type declarations in the syntax you might guess that Scheme is a dynamically typed language, which means that type is a property of objects rather than a property of the variables that name the objects. This is correct. On the other hand, it is possible to imagine a language like Scheme that is statically typed (i.e., it associates types with variables rather than objects). The language ML (see reference 2) is such a language. Though ML is statically typed, it does not require type declarations because the ML compiler can usually infer the types of variables by observing how they are used.

Statically typed languages are more restrictive than dynamically typed languages, but ML is much less restrictive than conventional languages because it lets you write polymorphic procedures that can work with arguments of many different types. A sort procedure, for example, can accept a list of integers or a list of symbols as its first argument, and can accept as its second argument a procedure that defines an ordering on the elements of the list. Scheme and other dialects of Lisp are even less restrictive than ML, because dynamic typing is an extremely simple and general (though some would say crude) form of polymorphism. The main disadvantage of dynamically typed languages is that they cannot catch type errors at compile time.

Should procedure calls pass their arguments fully evaluated (by value) or unevaluated (by name)? Algol 60 let the programmer choose, but most conventional languages since then have passed arguments by value, or have used a variation of pass-by-value, such as FORTRAN's pass-by-reference.

Scheme passes arguments by value because it gives the programmer more control over space/time trade-offs and the order in which side effects occur. Modern languages that don't have side effects often pass arguments by name because pass-by-name is potentially more time-efficient and has a very general substitution property that is useful when thinking about programs.

Should arguments be copied or should the argument itself be passed? In Scheme, objects are pointers, so the argument object will itself be passed as a pointer, but the structure pointed to will not be copied. Assignments do not copy objects either. Suppose that x names a string. Then `(set! y x)` makes y name the same string as x, not a copy. Also, suppose that the string x is passed to the procedure

```
((lambda (z) (string-set! z 0 #\:))
  x)
```

This procedure will store a colon into element 0 of that string (the prefix `#\` defines the colon as a character object). The value of x is unchanged—x still names the same string as before, but that string's contents are changed. This way of looking at objects may seem strange, but it is the right way to think about Scheme, other dialects of Lisp, and many other advanced languages.

The semantics of a programming language should answer all questions such as these.

Semantic Model

The semantics of Scheme is based on a conventional machine model, in which the computer's memory plays a large role. The memory is a set of locations where objects can be stored. A store is a particular configuration of memory. For each location, the store tells what is stored at the location.

The semantics of Scheme would be simpler if the model didn't involve memory and stores. They are necessary only because Scheme expressions can have side effects on the program state. Many programming language designers have concluded that side effects are not worth the semantic complications they cause (see reference 3). In some algorithms, however, it appears that the only way to avoid using side effects (in the form of

continued

All Scheme objects are first-class citizens of the language.

nonlocal variables whose values change within the procedure) is to pass extra arguments to every procedure in the program. Side effects improve modularity in such cases.

Though a store is needed to explain the semantics of Scheme expressions, the meanings of entire programs are ultimately the only ones that matter. This lets an optimizing compiler keep variables in registers instead of memory whenever it can prove that this does not change the meaning of the program.

First-Class Objects

All Scheme objects are endowed with certain inalienable rights:

- Objects have the right to remain anonymous.
- Objects have an identity that is independent of any names by which they may be known.
- Objects can be stored in variables and in data structures without losing their identity.
- Objects may be returned as the result of a procedure call.
- Objects never die.

All Scheme objects are first-class citizens of the language. In most programming languages, the only first-class objects are those that can easily fit into a machine register, like numbers, Booleans, and pointers. While numbers may be used without being given names, procedures may not; while characters and pointers may be stored, strings may not; while Booleans live forever, vectors may die when the procedure that created them returns. Thus, Scheme is very unusual in this respect. In fact, Scheme is the most widely used procedural language in which all objects are first-class.

Though objects never die, they may become inaccessible and therefore useless. Implementations of Scheme and other advanced languages may in fact reclaim the storage occupied by an object, provided they can prove that the object will never again be used. Algorithms for performing these proofs are known as garbage-collection algorithms.

Semantic Concepts

Before plunging into the details of a programming language's semantics, it helps to ask a few questions: What kinds of things can be stored in a memory location? What kinds of things can result from evaluating an expression? What kinds of things can variables name? The answers to these questions are known as the stored values, the expressed values, and the denoted values of the language.

In Scheme, the stored values are the same as the expressed values, because all objects are first-class. The denoted values, however, are tricky: In Scheme the denoted values are *locations*, not objects.

Variables name objects in two steps, as illustrated in figure 1. A variable directly names a location in memory. That location holds the object (i.e., the pointer that defines the object) we usually think of as the value of the variable. Thanks to this two-step naming process, which is used by nearly all major programming languages, there are two ways to change what a variable names. Through *binding*, the variable can be made to refer to a different location. Through *assignment*, a different object can be stored in the location the variable is bound to. In Scheme, binding is performed by lambda expressions, while assignment is performed by assignment expressions.

A store can be thought of as a dictionary with an entry for each location, telling what object is stored in the location. Most entries will of course say that the location is uninitialized; that is, no object is stored in the location, because the location is not yet in use. An environment, analogously, is a dictionary with an entry for each variable, telling the location to which the variable is bound. Most entries will of course say that the variable is unbound; that is, the variable is not yet bound to any location. Environments and stores are both illustrated in figure 1.

Splitting the naming process into these two steps is necessary to explain *aliasing*, a phenomenon in which two variables name the same location. Aliasing is responsible for pathological behavior in which an assignment to one variable changes the value of another. Scheme variables never suffer from this particular pathology, but it is possible for Scheme data structures (notably lists) to share structure, which is a form of aliasing. Environments and stores are also needed to explain the semantics of procedures in Scheme and other block-structured languages.

When a lambda expression is evaluated, the resulting procedure remembers the environment in which the lambda expression was evaluated; the procedure does not remember the store. When the procedure is called later, several things happen. The procedure allocates a new location for each of its formal arguments and stores each actual argument object in the corresponding new location. This results in a new store. The procedure then binds its formal arguments to the new locations. The binding works by creating a new environment that is like the remembered environment except that the formal arguments now refer to the new locations. The body of the lambda expression is then evaluated in the new store and new environment.

A procedure call (E0 E1 ...) is assessed by evaluating the expressions E0, E1, ... in any order. The results of the argument expressions are then sent, as the actual arguments, to the result of the expression E0, which should be a procedure. An implicit argument is also sent, representing the continuation to which

continued

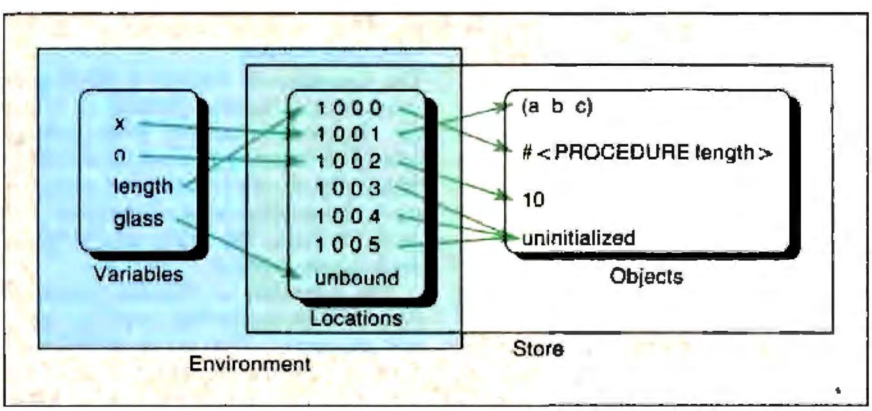

Figure 1: *The binding and assignment of variables. In the environment of a computer,* binding *is the process by which a variable is associated with a memory location. In the store,* assignment *is the process by which a location is associated with an object elsewhere in memory. Most high-level languages change variables by assignment; in Scheme it is more common to change a variable by altering its binding.*

the procedure should return its result.

(To describe it more fully, the *continuation* represents the total context of the rest of the program that specifies what is to be done with the results of the procedure call. It corresponds to the control stack in languages like C or Pascal, and it supplies the control context for the procedure being called, just as the environment remembered by the procedure supplies the name context.)

In listing 1, for example, the continuation for the recursive call to `length` will say to add 1 to the result of the call. Then it will say to return the result of that addition to the implicit continuation that was sent to `length` by the procedure that originally called it.

In listing 2, on the other hand, the continuation for the recursive call to `length2` (within the body of `length2`) will be exactly the same as the continuation that was originally sent to `length2`. In listing 1, a new continuation has to be created for each recursive call to `length`, but no new continuation has to be created for recursive calls to `length2` in listing 2 because the original continuation can be used. This means the definition in listing 2 will usually run quite a bit faster than the definition in listing 1.

Procedure calls for which no new continuation must be created are said to be *tail-recursive*. One advantage to semantics that explain procedure calls in terms of continuations, as opposed to a more traditional model in which procedures always return to the place where they were called, is that Scheme does not need any primitive expressions for performing iteration: Tail-recursive procedure calls, as in listing 2, are as efficient as iteration when compiled properly.

Derived Expressions

Though the kinds of expressions that have been explained so far are sufficient by themselves, it is convenient to have other kinds that express common idioms. For example, a nested conditional expression such as

```
(if (= n 0)
    0
    (if (= 1)
        1
        (+ (f (- n 1)) (f (- n 2)))))
```

can be replaced by a `cond` expression:

```
(cond ((= n 0) 0)
      ((= n 1) 1)
      (else (+ (f (- n 1)) (f (- n
2)))))
```

Local variables may be introduced by a `let` expression, where, for example,

```
(let ((x 3) (y 4))
  (* x y))
```

is equivalent to

```
((lambda (x y) (* x y))
 3
 4)
```

and of course evaluates to 12. Internal definitions, such as the definition of `length2` in listing 2, are more complicated to explain. They are actually part of an extended syntax for lambda expres-

Listing 2: *A tail-recursive definition of the* `length` *procedure. Because* `length2` *is tail-recursive, it uses less memory and runs faster than the* `length` *procedure in listing 1.*

```
(define (length x)
  (define (length2 x n)
    (if (null? x)
        n
        (length2 (cdr x) (+ n 1))))
  (length2 x 0))
```

Listing 3: *One possible equivalent for* `(while E0 E1)`. *Lines 1 and 2 bind* `E0` *and* `E1` *to the names* `test` *and* `loop`. *The* `define` *syntactic form in lines 3 through 5 define a procedure* `loop`, *and line 6 calls it.*

```
(let ((test (lambda () E0))
      (body (lambda () E1)))
  (define (loop)
    (if (test)
        (begin (body) (loop))
        #f))
  (loop))
```

sions and derived expressions that expand into lambda expressions (see reference 1). For now it should be enough to know that internal definitions are like the declarations at the head of an Algol 60 block. When the internal definitions define a set of procedures, they are like local procedure definitions in Modula-2 (or Pascal, except that forward references work).

Normally, Scheme will not guarantee any specific sequence for the evaluation of the expressions in `(E1 E2 E3 ...)`. However, you can specify left-to-right evaluation using `begin`, where `(begin E1)` is equivalent to `E1` and `(begin E1 E2 ...)` is equivalent to

```
((lambda (first rest) (rest))
 E1
 (lambda () (begin E2 ...)))
```

The reason this works, even though the order of evaluation of arguments is undefined in Scheme, is that the two lambda expressions evaluate to procedures without evaluating the procedure bodies. Even if `E1` is evaluated after the two lambda expressions, therefore, it will be evaluated before `E2`. Notice also that `E2` will be evaluated in the same environment as `E1`. The variables `first` and `rest` bound by the first lambda expression will not be visible to `E2` because the semantics of lambda expressions says the body of the lambda will be evaluated in an environment that is just like the environment the lambda expression itself was evaluated in, except for any variables bound by that lambda expression.

Scheme has two kinds of derived expressions, "named `let`" and `do`, that make iteration more convenient. Both are too complicated to explain here, but you can imagine the basic idea with a fictional kind of expression, the `while` loop, such that `(while E0 E1)` might expand into the code that appears in listing 3.

For Further Study

The books in references 4, 5, and 6 are all university-level textbooks recommended to those who want to learn more about the semantics of programming languages.

The current Scheme standard is described both informally and formally in the "Revised³ Report on the Algorithmic Language Scheme" (see reference 1). *The Little Lisper* (see reference 7) is a good introduction to Scheme and to recursive thinking. Mike Eisenberg's *Programming in Scheme* (see reference 8) is a more extensive introduction to Scheme. Many universities use Sussman and Abelson's challenging textbook *Structure and Interpretation of Computer Programs*, written for the introductory computer science course at MIT (see reference 9). It uses Scheme as its programming language.

Implementations of Scheme are available for the IBM PC and compatibles, Macintosh, DEC VAX, and several workstation-class computers. The book in reference 10 is also a reference for Chez Scheme, an implementation available on the VAX. The T programming language, described in reference 11, is a variant of Scheme found on larger machines. A portable implementation, written in C and Scheme, is available from MIT and can be ported to most sufficiently large computers. For more information, see the Lisp Resource Guide on page 236.

Common Lisp is another popular dialect of Lisp (see reference 12). While like Scheme in some respects, its semantics are substantially more complex. Many different implementations are available. ■

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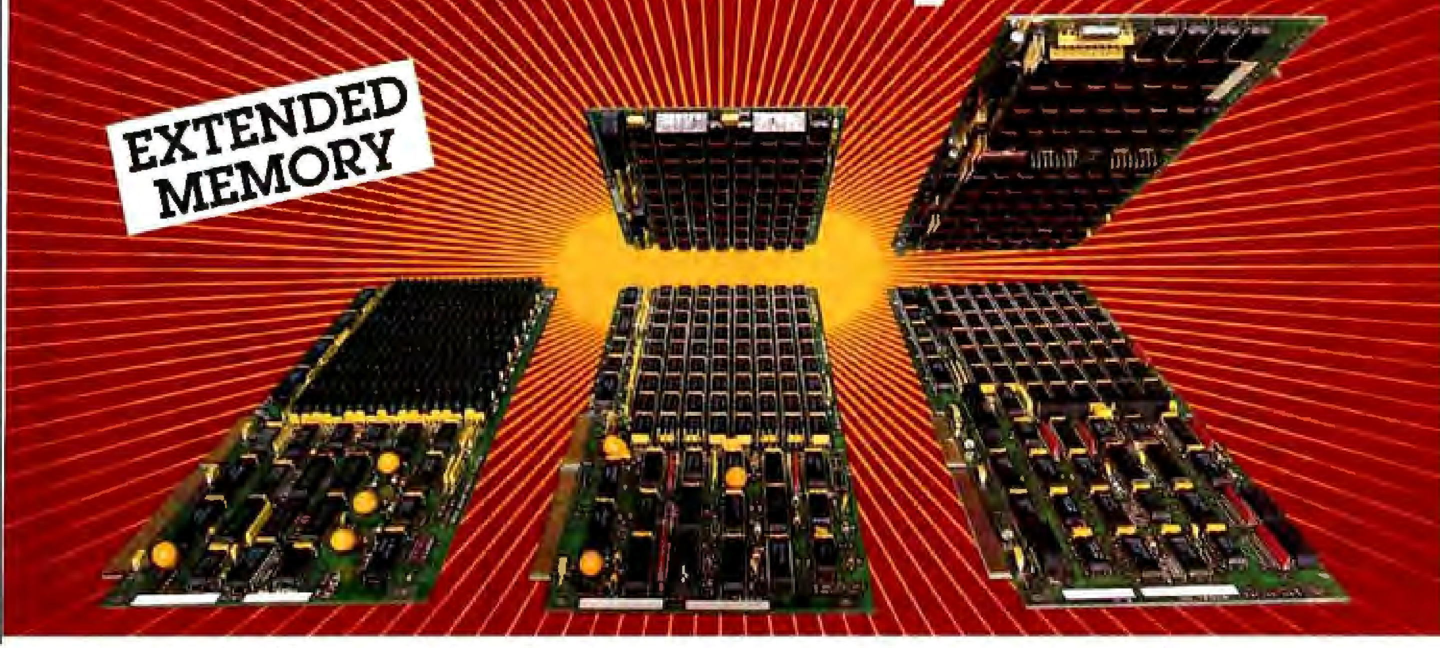

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How Lisp Has Changed

After 30 years, Lisp has evolved to be both versatile and powerful

David S. Touretzky

LISP ISN'T WHAT it used to be. The earliest dialect, described in the 1962 classic *The LISP 1.5 Programmer's Manual* by McCarthy et al., attracted little attention outside of a few artificial-intelligence (AI) laboratories. In fact, for most of its 30-year history, Lisp remained an orphan, with neither a standard definition nor interest from any computer manufacturer.

Today, Lisp is big business. Commercial vendors of Lisp compilers and Lisp-based AI applications earn millions from product sales and stock offerings. Textbooks and reference manuals abound; each year thousands of people purchase Guy L. Steele's *Common LISP: The Language*. An ANSI committee, X3J13, is at work on a standard to be based on Common Lisp. No longer an orphan, Lisp now has widespread support from almost all major computer manufacturers.

Unlike some of the other authors in this issue, I will focus on Common Lisp rather than Scheme. Scheme is a small, elegant language, while Common Lisp is a large, powerful one. Common Lisp borrowed the notion of lexical scoping from Scheme, and I'll have more to say about that later. The thrust of this article is the way Lisp has changed over the years.

Data Types

One of the most basic aspects of Lisp's evolution is the maturation of its type system. The only data types in Lisp 1.5 were symbols, numbers, and lists, the latter being chains of cons cells. All other objects, such as programs, trees, stacks, sets, tables, and so on, were built from conses. [Editor's note: *A cons cell, or cons, is a unit of storage within a Lisp list; its first element points to an element of the list, while its second element points to either NIL (denoting the end of the list) or the cons cell holding the next element. A list is represented internally as a linked list of cons cells.*]

The unifying role of conses is one of the strengths of Lisp; its many list primitives make it easy to manipulate other data types without a lot of redundant programming. For example, in Lisp (but not in strongly typed languages such as Ada), the same `length` function that returns the length of a list can also compute the cardinality of a set, the depth of a stack, or the size of a table.

Recently, however, conses have been given a slightly less prominent role in the language. Since many performance-critical programs, such as text editors, networking software, and window systems, are now written in Lisp, the use of `defstructs` (Lisp record structures) for performance reasons has become widespread. Normally, `defstructs` are implemented as vectors rather than lists; this allows their components to be accessed more efficiently.

Common Lisp contains a number of more exotic data structures not found in most other languages: ratios; bignums (integers with an unbounded number of digits); four flavors of floating-point number with varying degrees of precision (short, single, double, and long); complex numbers, whose components can be of any of several types; character objects; and hash tables. Here are some examples:

```
> (/ 2 8)
1/4     ;a ratio

> (float 1/4 0d0)
0.25d0     ;a double float

> (fact 20)
2432902008176640000 ;a bignum

> (+ 3 (sqrt -4))
#C(3 2)  ;complex:  3+2i

> (elt "ABC" 0)
#\A  ;character object A
; elt returns the n-th element
```

The Common Lisp type hierarchy is extensible. New record types, defined by `defstruct`, are automatically added to the type system, so that primitives such as `typep` and the `check-type` macro will recognize them. Users can also define their own types directly with `deftype`. Although Lisp still does not require type declarations for variables or functions, Common Lisp does provide a way to specify this information, via optional declarations in lambda expressions and certain other forms. Compilers can often

continued

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generate more efficient code if they are given type information, but the semantics of the program do not change.

Another important change in Lisp is that there is now better support for applicative and iterative programming styles. Applicative programs try to avoid side effects, including assignments, primarily for reasons of clarity and theoretical elegance, but also because applicative programs are easier for compilers to understand, which means they can generate better code.

In other languages, assignments are commonly used to hold on to a value temporarily and to perform an iteration. In Lisp, the `let` special form can be used to *bind* a new local variable—that is, to temporarily associate a value with that symbol; there is no need to use an assignment. Also, a variety of built-in iteration forms eliminate the need to code iterations by hand using prog and go. Listing 1a shows several functions written in the old Lisp programming style; listing 1b shows versions in the new, assignment-free iterative style. Modern Lispers almost never need to use prog and go.

Keyword Arguments

Another important change introduced by Common Lisp is the use of keyword arguments to basic list functions, which adds considerable flexibility and cleans up a problem with equality tests that earlier dialects solved less elegantly. In dialects such as MacLisp, `(member x y)` used the `equal` predicate to check whether x was equal to any element of y. Another function, `(memq x y)`, used eq as the equality test. A good programmer would use `memq` rather than `member` whenever possible, because eq is the most efficient equality predicate in Lisp: It compares two addresses, which means it can compile into a single machine instruction.

In contrast, the `equal` predicate must dispatch on the types of its arguments. If they are symbols, it compares their addresses; if they are numbers, it compares their values; if they are lists, `equal` must call itself recursively to check corresponding elements for equality. A few other functions in the older dialects also had parallel versions defined using eq instead of `equal`, such as `assq` for `assoc` and `delq` for `delete`, but many other functions did not.

Common Lisp takes a different approach. List manipulation functions that perform equality tests accept an optional keyword argument, `:test`, which can be used to specify an alternative predicate. The default predicate is `eql`, which is similar to eq except it compares numbers correctly. In Common Lisp, `(member x y)` is exactly equivalent to

```
(member x y :test #'eql)
```

The notation `#'eql` is shorthand for `(function eql)`; `#'` is the correct way to quote a function in Common Lisp. To obtain the functionality of the old MacLisp member predicate, you would write

```
(member x y :test #'equal)
```

The value of the `:test` keyword can be some other sort of comparison than equality. For example, if y were a list of numbers and we wanted to find the sublist beginning with the first number greater than x, we could write

```
(member x y :test #'<)
```

There are several other built-in keywords besides `:test`. The `member` function also accepts a `:key` keyword. If x is a list of lists, to find the first list beginning with foo, one would write

```
(find 'foo x :key #'car)
```

Sequences and Assignments

Although many Lisp dialects include vectors and arrays, Common Lisp is the first

continued

Listing 1: *These definitions of* `test-last`, *the Lisp 1.5* `assoc` *function, and the classic factorial function* (`fact`) *in listing* **(a)** *are written in an old-fashioned Lisp style. They would earn a failing grade for their unnecessary use of assignments and poor choice of control structure. Their counterparts in listing* **(b)** *are written in modern Lisp style and contain no explicit assignment statements. The* `dolist` *macro steps a variable through the elements of a list. The* do *macro is simultaneously stepping two index variables,* `i` *and* `res`, *in parallel until* `i` *is zero.*

(a)

```
; TEST-LAST returns T if the first or second element of X
; is equal to the last element.  It saves the value of
; (CAR (LAST X)) to avoid having to compute it twice.
(defun test-last (x)
  (prog (temp)
        (setq temp (car (last x)))
        (return (or (equal (car x) temp)
                    (equal (cadr x) temp)))))


(defun assoc (x y)
  (prog ()
   loop
        (cond ((null y) (return nil))
              ((equal x (caar y)) (return (car y)))
              (t (setq y (cdr y))
                 (go loop)))))


(defun fact (n)
  (prog (res)
        (setq res 1)
   loop
        (if (<= n 1) (return res))
        (setq res (* n res))
        (setq n (- n 1))
        (go loop)))
```

(b)

```
(defun test-last (x)
  (let ((temp (car (last x))))
    (or (equal (first x) temp)
        (equal (second x) temp))))


(defun assoc (x y)
  (dolist (e y)
    (if (equal x (car e)) (return e))))


(defun fact (n)
  (do ((i n (1- i))
       (res 1 (* i res)))
      ((zerop i) res)))
```

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to unify lists and vectors under the more general notion of "sequence." Functions previously defined only for lists, such as `length`, `reverse`, and `remove`, have been extended to sequences, so they now operate on strings, ordinary vectors, and bit vectors as well. Several dozen new sequence functions have been added, and the entire collection has been extended to take a variety of keyword arguments. Programmers can write virtually all the sequence manipulations that they used to code by hand with some combination of built-in sequence functions.

Listing 2: *A recursive-descent parser in Common Lisp. Even though this program solves a nontrivial problem, it does not contain a single assignment statement.*

```
(defvar *grammar* nil
  "The grammar represented as an a-list.")

(defun terminalp (x)
  (not (assoc x *grammar*)))

(defun parse (input)
  (car (parse-symbol 'S input)))

(defun parse-symbol (sym input)
  (if (terminalp sym) (parse-terminal sym input)
      (parse-nonterminal sym input)))

(defun parse-terminal (sym input)
  (if (eql sym (first input))
      (values (list sym) (rest input))
      nil))

(defun parse-nonterminal (sym input)
  (dolist (rule-seg (cdr (assoc sym *grammar*)))
    (multiple-value-bind (result remainder)
        (parse-rule rule-seg input '())
      (if result
          (return (values (list (cons sym result))
                          remainder))))))

(defun parse-rule (rule-seg input earlier-parse)
  (if (null rule-seg) (values earlier-parse input)
      (multiple-value-bind (result remainder)
          (parse-symbol (first rule-seg) input)
        (if result
            (parse-rule
              (rest rule-seg)
              remainder
              (nconc earlier-parse result))))))
```

Listing 3: *A sample grammar for testing the parser. The grammar is represented as an association list of rewrite rules. The first entry says that a sentence,* S, *consists of a noun phrase,* NP, *followed by a verb phrase,* VP. *The second entry gives four rewrite rules for noun phrases.*

```
(setf *grammar*
  '((s          (np vp))
    (np         (nprop) (pro) (art adjlist n) (art n))
    (nprop      (john) (mary))
    (pro        (he) (she) (it))
    (art        (the) (a))
    (adjlist    (adj adjlist) (adj))
    (adj        (big) (little) (red) (tasty))
    (n          (boy) (girl) (ball) (pizza) (stick))
    (vp         (vi) (vt np) (vrel relc))
    (vi         (laughed) (sang))
    (vt         (threw) (kicked) (ate))
    (vrel       (saw) (said) (thought))
    (relc       (that s))))
```

One advantage of building more list and sequence functions into the language is that it allows the compiler to generate more efficient code for them. For example, such functions can be *open coded*, which means the compiler generates machine instructions to implement them directly rather than perform a subroutine call.

Another area where Common Lisp takes a cleaner, more comprehensive approach than previous dialects is the treatment of assignment. Earlier Lisps provided one way to store values in variables (`setq`), two ways to store into cons cells (`rplaca` and `rplacd`), a different way to store into property lists (`putprop`), yet another way to store into vectors or arrays (`store`), and so on. Common Lisp has a notion of "generalized variable," which is any place a pointer may reside.

All forms of assignment are handled by a single macro called `setf`. The first argument to `setf` describes the place where the value is to be stored; the second argument is the value. The `setf` macro expands into implementation-dependent code depending on the place description, which may be quite complex. Users can even define their own kinds of places (with `defsetf`) and tell Lisp how to generate code to store things there. Several operations derived from assignment are defined on generalized variables; by convention, their names generally end with the letter *f*. Here are some examples: `incf` increments a variable, and `rotatef` rotates values among a set of variables.

```
> (setf x '(a b c))
(A B C)

> (setf (second x) 99)
99

> x
(A 99 C)

> (incf (car (cdr x)) 2)
101

> x
(A 101 C)

> (rotatef (first x)
           (second x))
NIL

> x
(101 A C)
```

[Editor's note: *Common Lisp stores and displays all symbols in uppercase; if you type in lowercase symbols, Common Lisp converts them to uppercase before storing them. However, the convention is to* *refer to Common Lisp symbols as lowercase when the difference makes the text more readable.*]

Although assignment is syntactically more elegant in Common Lisp than in many previous dialects, the most semantically elegant programs are those with no assignments at all. This point is discussed in more detail in the article by William Clinger on page 221 of this issue. Listing 2 shows a recursive-descent parser written in Common Lisp without a single assignment. Listing 3 specifies a test grammar for it, and listing 4 shows it parsing some example sentences. The grammar resides in a global variable called `*grammar*`. By convention, Common Lisp programmers begin and end the names of global variables with an asterisk.

The `parse-symbol`, `parse-nonterminal`, and `parse-rule` functions all return two values instead of one; they use the `values` special form to accomplish this. The first value is a list of subtrees for segments of the input already matched; the second is a list of remaining input tokens. Returning multiple values directly on the stack is more efficient than consing a list of them and returning the list. A specialized binding form, `multiple-value-bind`, is used instead of `let` to hold on to values when a function returns more than one of them.

Lexical Scoping

Common Lisp borrowed the notion of lexical scoping from Scheme and uses lexical scoping by default, while earlier Lisp dialects were dynamically scoped. Basically, *lexical scoping* means that functions can access whatever bindings appear in their lexical environment, but no others. The *lexical environment* of a function consists of its local bindings, plus those of any form that textually contains the function. For example, in listing 5, the variable `n` that is local to `multiply-by` is part of the lexical context of the lambda expression that appears in the body of `multiply-by`.

[Editor's note: *To summarize, if the language is lexically scoped, you look to the surrounding code of the listing itself to see whether a symbol is bound. If it is dynamically scoped, symbols are considered bound until the procedure enclosing them returns, and you must look at the order in which procedures are evaluated to see whether a symbol is bound.*]

Unlike Scheme, Common Lisp retains dynamic scoping as an option available via special forms such as `declare` and `defvar`. Listing 6 illustrates both kinds of binding. In a dynamically scoped list, the fact that `test` bound a variable named x would prevent `access-vars` from accessing the global x it was intended to. Under lexical scoping, `test`'s x is a different variable than the global x and is not part of the lexical context of `access-vars`. On the other hand, the binding of y that `access-vars` sees is the one established by `test`; this is due to the `special` declaration, which requests dynamic scoping.

Common Lisp is the first Lisp dialect in which declarations can affect the semantics of interpreted programs. This feature makes Common Lisp interpreters rather more complex than other Lisp interpreters, but it does not affect the efficiency of compiled code. Unlike previous dynamically scoped dialects, Common Lisp programs always behave the same way interpreted as they do when they are compiled.

Another feature borrowed from Scheme, related to lexical scoping, is the notion of a *lexical closure*, a function packaged together with the environment in which it was defined. When the closure is called, it can reference the variables in its environment and even modify them. The next time it is called, the variables in its environment will again be accessible. Thus, local variables in Common Lisp

continued

Listing 4: *Sample output from the recursive-descent parser.*

```
> (parse '(the boy ate a tasty little pizza))
(S (NP (ART THE) (N BOY))
   (VP (VT ATE)
       (NP (ART A)
           (ADJLIST (ADJ TASTY) (ADJLIST (ADJ LITTLE)))
           (N PIZZA))))

> (parse '(john said that mary kicked the ball))
(S (NP (NPROP JOHN))
   (VP (VREL SAID)
       (RELC THAT
             (S (NP (NPROP MARY))
                (VP (VT KICKED)
                    (NP (ART THE) (N BALL)))))))
```

Listing 5: *This listing illustrates the creation of a lexical closure. Since the variable* `n` *is local to* `multiply-by`, *its binding would normally go away when the function returns. However,* `n` *is referenced in the body of the lambda expression to be returned by* `multiply-by`, *so a lexical closure is created whose environment references that binding; the binding will live on as long as the closure remains in existence.*

```
> (defun multiply-by (n)
    #'(lambda (x) (* x n)))
MULTIPLY-BY

> (setf doubler (multiply-by 2))
#<LEXICAL-CLOSURE 5350043>

> (setf tripler (multiply-by 3))
#<LEXICAL-CLOSURE 5410065>

> n    ;; note: there is no global variable N
Error:  N unbound variable.

> (describe doubler)
#<LEXICAL-CLOSURE 5350043> is a lexical closure.
Its function is (LAMBDA (X) (* X N)).
Its environment contains the bindings:
  N = 2

> (mapcar doubler '(1 2 3 4 5))
(2 4 6 8 10)

> (mapcar tripler '(1 2 3 4 5))
(3 6 9 12 15)
```

Listing 6: *Lexical and dynamic scoping in Common Lisp. The first two lines establish bindings for the global variables* x *and* y. *Function* `test` *binds a new variable named* x, *whose scope is local to* `test`, *and rebinds the global variable* y. *Function* `access-vars` *returns the value of the global variable* x *rather than the local* x *of* `test` *because the local variable is not within the lexical scope of* `access-vars`. *Variable* y *is treated differently because it is declared special, which means dynamically scoped. This causes* `test` *to rebind* y *rather than establish a new local* y.

```
(setf x 'global-x-value)
(setf y 'global-y-value)

(defun test (x y)
  (declare (special y))
  (access-vars))

(defun access-vars ()
  (list x y))

> (test 'new-x-value 'new-y-value)
(GLOBAL-X-VALUE NEW-Y-VALUE)
```

have potentially unbounded lifetimes, known as *infinite extent*. In earlier dialects, variables had *dynamic extent*, meaning they disappeared forever when a function returned.

Another important fact about lexical closures is that, depending on the context in which they were defined, several closures might share the same binding environment. Since closures are created automatically by Lisp when needed, and since you can make any number of closures over the same function (each with its own private environment), this feature is substantially more powerful than static variables provided by languages such as C. In listing 5, the `multiply-by` function returns lexical closures that multiply their input by a constant. Each closure contains a binding for n in its environment because n is local to `multiply-by` and is referenced by the body of the closure.

The Future of Lisp

The Common Lisp standard is incomplete in a number of places where the designers thought it would be premature to freeze the language. For example, although much of the recent research in object-oriented programming has been conducted in Lisp, beginning with the Lisp Machine's Flavors system, the Common Lisp Object System (CLOS) is still being designed; it is not yet part of the standard. CLOS will be similar to Portable Common Loops, an object system developed at Xerox Palo Alto Research Center (PARC) that is already quite popular among users of Common Lisp.

Further in the future there will be a `loop` macro (modeled after the Lisp Machine's Zetalisp `loop` macro) for expressing complex iterative algorithms in an English-like syntax, and a Common Lisp standard window system interface. An even more exciting prospect for Lisp is the introduction of support for parallelism. A number of experimental parallel Lisps already exist.

Lisp on Personal Computers

The gap between hobbyist and professional computing has narrowed substantially. Several full implementations of Common Lisp have recently been announced for IBM PC AT and Apple Macintosh Plus machines with sufficient memory. These are high-quality implementations that include compilers and sophisticated programming tools. Thanks to Common Lisp and improved hardware, we are entering an age when hobbyists will be able to run the same research software as university AI labs. Many of us find this prospect truly exciting. ■

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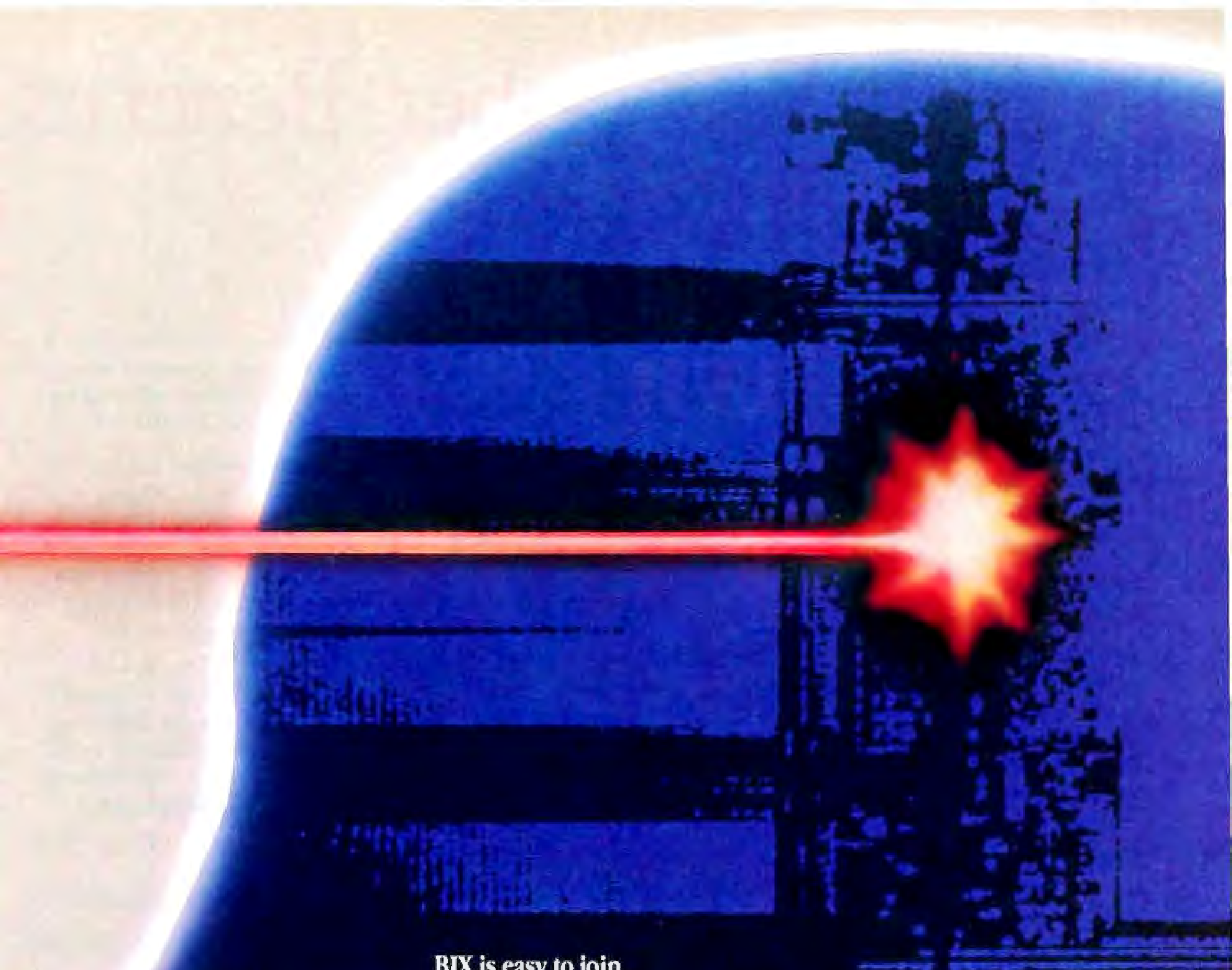

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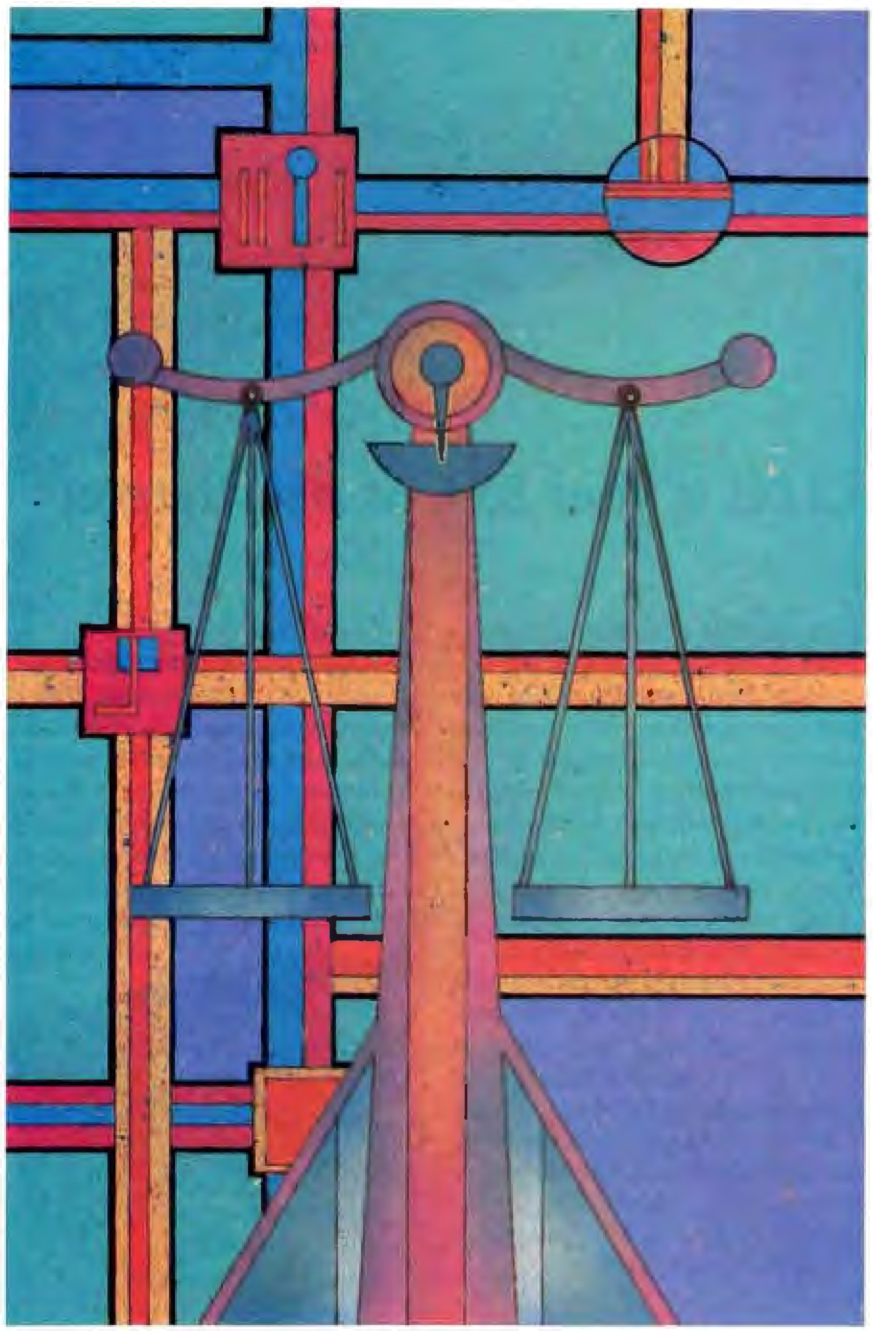

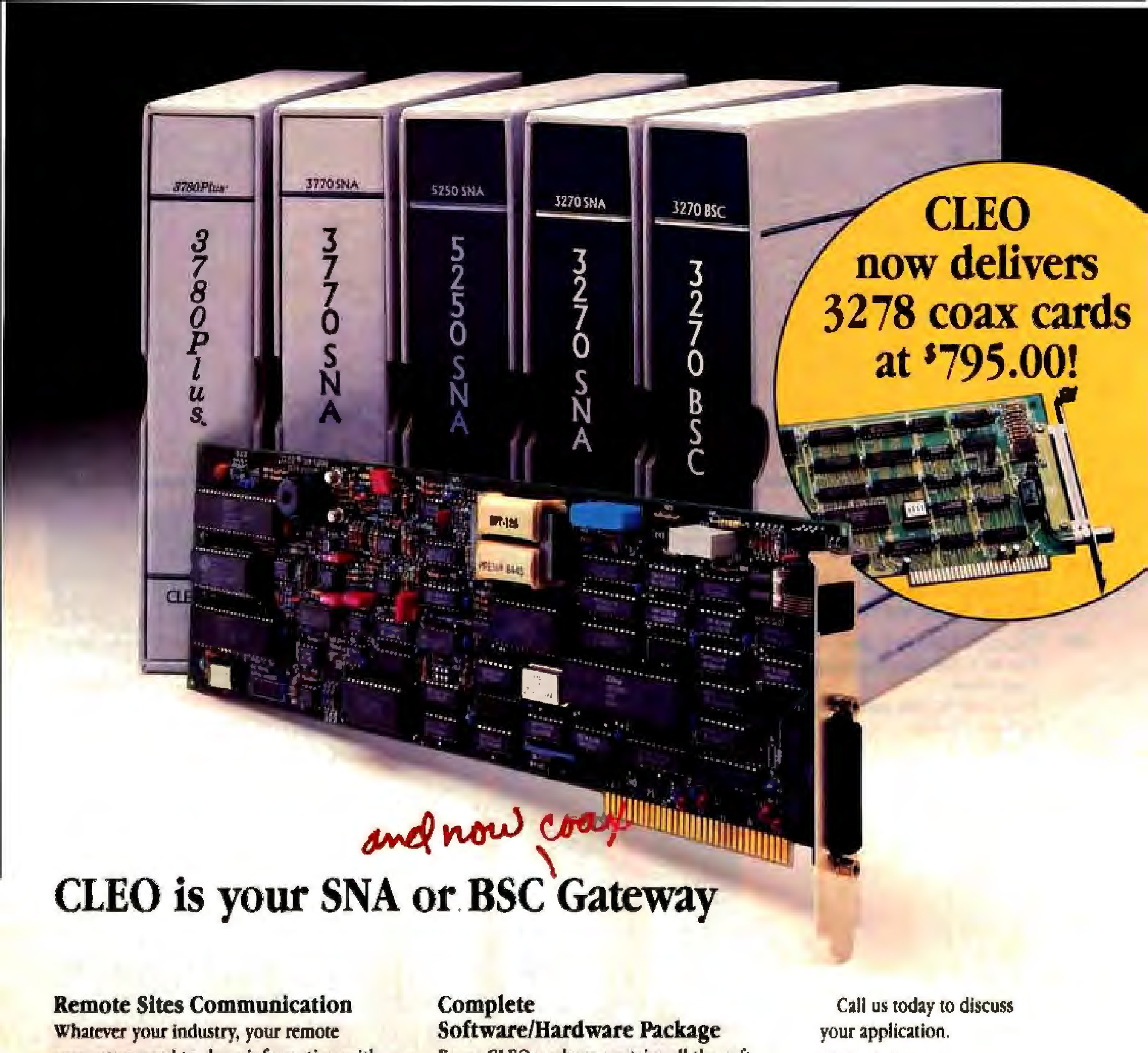

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CLEO®

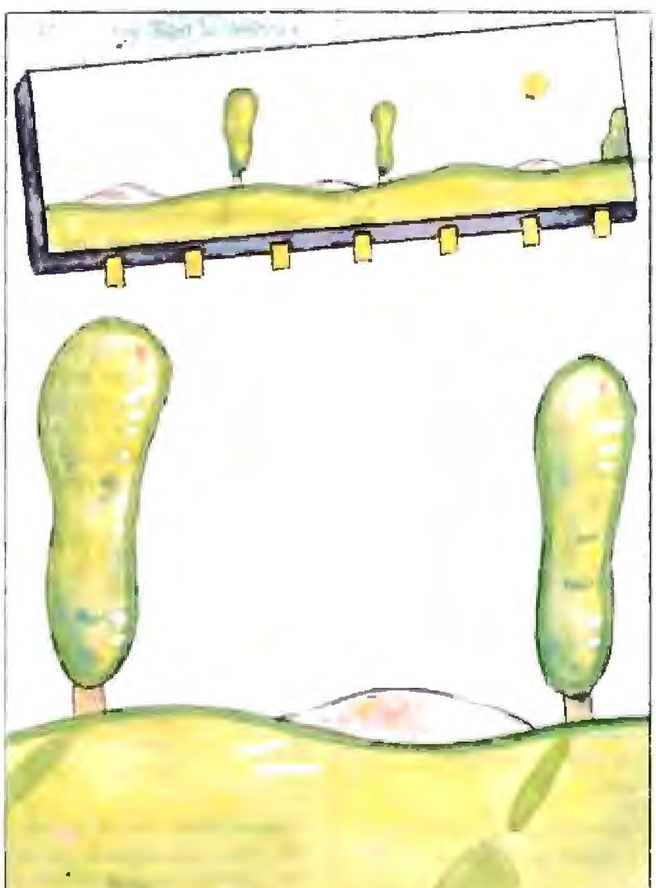
by Peter Immarco

The New LIM/EMS

Version 4.0 of LIM/EMS supports memory management, interprocess communication, and code execution.

A major revision of the Lotus/Intel/Microsoft Expanded Memory Specification (LIM/EMS), EMS 4.0 provides significant improvements over version 3.2. It also represents a much-needed unification and standardization of EMS.

EMS 4.0 is a superset of EMS 3.2. It has 30 functions (see table 1), the first 15 of which are identical to those of EMS 3.2. The additional functions support memory management and interprocess communication and make it easier to execute code from EMS memory. There is also added support for operating-system environments (such as Quarterdeck's DESQview and Microsoft Windows). I will concentrate on the improvements in EMS 4.0 and on how they translate into benefits to users and developers. [Editor's note: *For a discussion of EMS 3.2, see "Lotus/Intel/Microsoft Expanded Memory" by Ray Duncan in BYTE's* Inside the IBM PCs, *Fall 1986.*]



A Brief Review

The LIM Expanded Memory Specification was developed to allow programmers to write DOS applications that could address memory beyond DOS's 640K-byte limit. This limit originated with the Intel 8086/8088 microprocessor, which could address only a megabyte of memory. The memory below 640K, usually referred to as conventional memory, is occupied by DOS. The memory between 640K and 1 megabyte contains ROM code and video buffers, among other things.

The LIM/EMS uses a bank-switching technique to extend the addressing range of DOS. Expanded memory is divided into logical pages (typically 16K bytes) and mapped onto a physical block of memory. In EMS 3.2, this physical block of memory is located in unused portions of memory between 640K and 1 megabyte. With EMS 4.0, however, you can map logical pages anywhere within the first megabyte of address space, depending on the capabilities of the EMS hardware you are using. This physical memory is called a page frame and serves as a window into the actual expanded memory. A device driver, called an expanded memory (EM) manager, translates the expanded memory function calls into actual memory-management events using the expanded memory hardware.

Software drivers are available that can make extended memory look like expanded memory. Extended memory is the memory above 1 megabyte that the 80286 and 80386 can address. True expanded memory comes on a hardware board specifically designed to the LIM expanded memory specification.

When an application program requests expanded memory pages from the EM manager, it is given a handle number. This number is used by the application program when making any further calls to the EM manager. Expanded memory handle numbers are similar to file handle numbers returned by MS-DOS when you create or open a file.

Superior Memory Management

EMS 4.0 can address up to 32 megabytes of expanded memory, whereas version 3.2 had a maximum limit of 8 megabytes. In an application, there is a relationship between the

continued

Peter Immarco is the national sales manager for Thought Dynamics, makers of the terminate-and-stay-resident program, Fetch. You can reach him at 1142 Manhattan Ave., Suite CP-310, Manhattan Beach, CA 90266, or on CompuServe as CIS 73770,123.

Illustration by Catharine Bennett

logical pages and the physical pages. This is called the *mapping context*. The EM manager maintains this relationship for you once you have established it with the proper expanded memory function calls.

Several new calls in EMS 4.0 make it easier to manipulate memory. Under EMS 3.2, logical to physical pages were mapped one at a time, through reiterative calls to function 5 (Map/UnMap Handle Pages).

In version 4.0, function 17 (Map/UnMap Multiple Handle Pages) lets you map multiple logical pages onto multiple physical pages with a single function call. You do this by passing a list of paired elements, each containing one logical-to-physical-page relationship. By creating a list for each mapping context you will require, you can switch mapping contexts easily and conveniently. Another call, function 16 (Get/Set Partial Page Map), lets you save the mapping information for only the mappable memory regions that you select. Saving less information reduces the memory requirements and could increase the speed of your program.

Table 1: *The LIM/EMS 4.0 function calls include the 15 function calls of EMS 3.2. Functions 16 through 25 add support for memory management, interprocess communication, and they make it easier to execute code from expanded memory. Operating-system environment developers can use functions 26 through 30, to determine what hardware is present and to write environments that will work with nonstandard hardware.*

Functions 1 through 15 are identical to those in LIM/EMS 3.2

1	Get Status
2	Get Page Frame Address
3	Get Unallocated Page Count
4	Allocate Pages
5	Map/Unmap Handle Pages
6	Deallocate Pages
7	Get Version
8	Save Page Map
9	Restore Page Map
10	Reserved
11	Reserved
12	Get Handle Count
13	Get Handle Pages
14	Get All Handle Pages
15	Get/Set Page Map

Functions 16 through 30 were added in LIM/EMS 4.0

16	Get/Set Partial Page Map
17	Map/Unmap Multiple Handle Pages
18	Reallocate Pages
19	Get/Set Handle Attribute
20	Get/Set Handle Name
21	Get Handle Directory
22	Alter Page Map and Jump
23	Alter Page Map and Call
24	Move/Exchange Memory Region
25	Get Mappable Physical Address Array

For operating-environment developers only:

26	Get Expanded Memory Hardware Information
27	Allocate Standard/Raw Pages
28	Alternate Map Register Set
29	Prepare Expanded Memory Hardware for Warm Boot
30	Enable/Disable Operating System Environment

Under EMS 3.2, when your application required more expanded memory pages, you could not simply increase the number of pages controlled by the handle you were using. You had to request a new handle to hold the extra pages. This resulted in a real bookkeeping headache. When you wanted to access data residing in expanded memory, first you had to determine which expanded memory handles contained the data you were seeking.

To avoid these problems, many applications that used expanded memory under EMS 3.2 took all the expanded memory pages they found available when they began execution, leaving no pages for anyone else. EMS 4.0 now includes function 18 (Reallocate Pages), which lets an application increase or decrease the number of pages allocated to an expanded memory handle.

In EMS 3.2, if you wanted to transfer blocks of memory from one area to another, you had to use whatever memory-transfer facilities were available to you in the programming language you were using and perform the necessary validation checks yourself. Having the EM manager do this for you reduces the amount of work your application has to perform. Function 24 (Move/Exchange Memory Region) in EMS 4.0 lets you move or swap memory in four directions: conventional to conventional memory, conventional to EM, EM to conventional, and EM to EM.

One nice feature of function 24 is that it will tell you if the source and destination areas overlap. Overlap can occur if the source and destination handles are identical. In the case of a move operation, if overlap is detected, the function will choose the move direction such that the destination receives an intact copy of the source. The function will return a status flag informing you that the overlap occurred. In the case of an exchange operation, if overlap is detected, the function aborts the operation and returns a status flag to that effect.

EMS 3.2 was limited to a single contiguous page frame or window of 64K bytes. EMS 4.0 can map memory regions outside the EMS 3.2 defined window with function 25 (Get Mappable Physical Address Array). Function 25 has two subfunctions: Subfunction 0 returns a list of the addresses of all the memory regions available for mapping, and a relative physical page number for each of those addresses. This function tells you how big of an expanded memory window you have, and at what segment addresses the mappable pages that make up the expanded memory window are located. By examining the list returned, you can tell which portions of the expanded memory window are contiguous and which are not. Subfunction 1 tells you how much memory you will need to set aside to receive this list.

Expanded memory programmers who will be using expanded memory boards that support more than 4 pages (64K bytes) of mappable memory can use this function to determine how many physical pages they can map at one time. For example, an enhanced EMS board supports more than 4 pages of mappable memory by allowing you to map expanded memory into conventional memory. This method of mapping memory is called *backfilling*. The mapping might look like this:

Physical page address	Page number
9000h	04h
9400h	05h
E000h	00h
E400h	01h
E800h	02h
EC00h	03h

This example shows a total of 6 mappable pages (96K bytes). The physical page segment addresses are in ascending order and the physical page numbers are not. The segment addresses in expanded memory are first, and the conventional memory address segments are listed afterwards. Only the 4 pages at E000h and the 2 pages at 9000h are contiguous. This means that the data structures or code fragments you put in either of those expanded memory areas have to fit into a 32K-byte area partition or a 64K-byte partition, unless you maintain a table of pointers between the two contiguous data areas yourself.

You should not use function 2 (Get Page Frame Address) to map the pages listed by function 25. Function 2 was designed for boards with a single contiguous 4-page (64K) window and has no way of telling you where the other mappable segments are.

Interprocess Communication

In EMS 4.0, any program can use another program's expanded memory pages via the handle number. Under EMS 3.2 you had no way of finding out which active handle number belonged to which program. This is because there was no way to assign an identifying label to the integer handle number you were given when you requested expanded memory pages from the EM manager.

With EMS 4.0, you can now give that handle an eight-character ASCII name, using function 20 (Get/Set Handle Name). Conversely, function 21 (Get Handle Directory) lets you determine the handle number that belongs to a particular handle name.

These two functions make it simple to share data residing in expanded memory between separate programs. For example, let's say you've written a spreadsheet program that uses expanded memory. When the spreadsheet begins execution, it requests 20 pages of expanded memory and receives the handle number 7. It also assigns that handle the name "CALC-IT," using function 20. Let's say that you have a graphics print-spooling program that operates in the background. The print spooler uses function 21 to find the handle number associated with the handle name "CALC-IT" and gets number 7. Now the print spooler can share the data in expanded memory along with the spreadsheet program. Function 21 can also return a complete directory of all the active handles and their names, as well as the total number of handles that the EM manager will support. This function is useful for writing EMS utility programs. For example, function 21 makes it easier to write a utility that shows you all the active expanded memory handles and their names.

Easier Code Execution

With version 3.2, you could execute code in expanded memory, but it was a lot of work. You had to manually calculate the amount of storage space required for the operation, save the current mapping context, map in the new mapping context one page at a time, make a call to the proper address, and, after that code returned, restore the saved mapping context one page at a time.

EMS 4.0 has two functions that make it easier to execute code from expanded memory: function 22 (Alter Page Map and Jump) and function 23 (Alter Page Map and Call).

Function 22 is analogous to a Far Jump. You give the EM manager the target address of the code you want to branch to and the list of logical and physical pages you want it mapped to. In one stroke, the EM manager will alter the current mapping context to reflect the mapping context you gave it and transfer control to the target address. Be aware that it does not save the mapping context that existed before you called function 22.

Function 23 is like a Far Call; it differs from function 22 in that the mapping context is automatically saved before control transfers to the target address. You give the EM manager a pointer to a buffer that reserves a place for the EM manager to store the current mapping context and contains the new mapping context. When the Far Return is executed, control returns to the next instruction after the calling point. Because function 23 puts information on the stack, there is a subfunction that tells you the number of memory bytes you need to set aside for the stack.

To improve interprocess communication, EMS 4.0 has added two functions that make it simple for separate programs to share data residing in expanded memory.

Miscellaneous New Features

Two functions work together in EMS 4.0 to preserve data across a warm boot: function 19 (Get/Set Handle Attribute) and function 29 (Prepare Expanded Memory Hardware for Warm Boot). (Function 29 is intended for operating-environment developers; I will describe it in the next section.) Function 19 lets you designate specific handles as volatile or nonvolatile. EMS pages associated with a nonvolatile handle are preserved across a warm boot. You can query the EM manager to see whether a certain handle number is volatile or nonvolatile, or whether the EM manager supports this feature. Assuming an EM manager is in accordance with the EMS 4.0 specification, it will return a Not Supported status if the expanded memory hardware does not support the nonvolatile attribute. To support the nonvolatile attribute, the expanded memory board must have its own memory-refresh controller; it cannot be dependent on the computer system's refresh controller.

Improved Multitasking

Functions 26 through 30 are intended for operating-system-environment (OS/E) developers only. However, for the sake of completeness, I will describe them briefly.

Some of the more advanced expanded memory hardware systems support alternate register sets, which can store an alternate mapping context. With this feature, OS/E developers can perform context switching by switching register sets rather than by saving and restoring the mapping context via software. The more alternate register sets an expanded memory environment has, the more tasks it can switch quickly.

Through the use of function 26 (Get Expanded Memory Hardware Information), the OS/E developer can determine what hardware-based facilities are available. The items returned by this function are the raw-page size, the number of alternate mapping register sets, the context-save area size, the number of register sets that can be assigned to DMA (direct memory access) operation, and a flag that tells what kind of channel operation the DMA register sets follow.

A raw page is the smallest amount of memory in kilobytes that the expanded memory environment present can use. The EMS standard is designed around a page size of 16K bytes; however, EMS 4.0 allows hardware to use differing raw-page sizes. For example, an OS/E developer can allocate pages in an 80386 system in 4K-byte increments. The context-save area size lets you know how much memory storage in bytes it requires to save a mapping context.

You can also assign certain register sets to DMA channel operations to greatly enhance the ability to multitask. Let's say you have an applications program that has initiated a DMA operation whose destination is expanded memory. Until this operation is completed, you cannot change the current mapping context. Otherwise, the DMA controller will write on top of any

continued

Cooperation between the major players in the microcomputer market in regard to EMS 4.0 has resulted in better and safer development tools for the programmer, which can only lead to better applications for the user.

data or code that has been swapped into the expanded memory window. Through the use of DMA register sets, you can perform context switching even though a DMA operation might still be in progress. The DMA register set can direct the DMA write operations into the expanded memory pages that were mapped in the expanded memory window when the DMA operation began. Even though the current mapping context has changed, the DMA write operation can still finish.

If the value returned by function 26 for DMA channel operation is a one, then the expanded memory environment has only one DMA register set, and if one DMA channel is mapped through this set, then all DMA channels will be mapped through it. If it is zero, then the DMA register sets can be assigned to the DMA channels on a one-to-one basis, depending on how many register sets there are and how many DMA channels there are.

Function 27 (Allocate Standard/Raw Pages) allocates raw pages to the operating system. Raw pages are pages that are of nonstandard length and must be handled differently than standard size (16K-byte) pages. When you make a function 27 request, a raw handle is returned. It is the EM manager's responsibility to recognize raw handles and treat all functions that are called by a raw handle differently.

Function 28 (Alternate Map Register Set) contains a full set of functions to get and set, allocate, and deallocate the alternate map register sets. In addition, it can enable and disable DMA operations on the DMA register sets and control the assignment of DMA channels to DMA register sets.

You must call function 29 (Prepare Expanded Memory Hardware for Warm Boot) before you execute a warm boot. The EM manager will then take responsibility for maintaining the current mapping context, the mapping and alternate register sets, and any other expanded memory hardware dependencies that need to be initialized at boot time.

Through Function 30 (Enable/Disable Operating System Environment), the OS/E can disable the use of functions 26, 28, and 29, thus ensuring a safe operating environment. The first time the OS/E calls function 30, it is given a double-word access key. After that, any calls to function 30 to enable or disable the OS/E functions must be accompanied by that access key.

The Future of EEMS

AST Research has joined in supporting EMS 4.0 as the new standard for expanded memory. The company will release a driver that meets 4.0's specification. I've been told that this driver will also support software written to the EEMS specification by accepting the EEMS calls that such an application would make, while fully supporting the EMS 4.0 function call set.

Existing EMS 3.2 software will work just as before. EMS 4.0 is a superset of the function calls in version 3.2 and maintains full backward compatibility with applications written for version 3.2. Software written to take advantage of 4.0's advanced features, however, will not operate under version 3.2.

To upgrade from EMS 3.2 to 4.0, you will not need to buy any new hardware. What you will need is a new EMS driver from the manufacturer of your expanded memory board or expanded memory software emulator. In many cases, these upgrades will come at little or no charge.

Software-only emulators that do not use any hardware mapping registers at all may conflict with some software written for EMS 4.0. Software-only emulators cannot support data aliasing. Data aliasing is a feature of expanded memory hardware environments that allows you to map multiple logical pages onto the same physical page. For instance, you can map logical pages 0 and 1 onto physical page 0. Therefore, any data writes to either of those logical pages will affect physical page 0. In fact, the EMS 4.0 specification lists this as one way to test for the presence of a software-only emulator.

According to some of the major applications software vendors, you might be able to run their software without any conflict using your expanded memory software-only emulator; but if you do and you discover a problem, they will tell you that they don't endorse using them. Proceed at your own risk, or call the manufacturers of your applications software and your EMS software emulator and ask them for EMS 4.0–compatibility information.

To Multitask or Not to Multitask

The ability to multitask depends on your expanded memory hardware or hardware-assisted software emulator. A purely software EM emulator does not use any hardware paging registers to perform mapping context switching. There are two styles of EMS boards: the Intel Above Boards (e.g., Intel Above Board/286), and the AST EEMS boards (e.g., AST Rampage). The Above Board is limited to a 64K-byte window while the EEMS boards can have a window equal to the entire DOS 640K-byte address space. To perform true multitasking, you must have an expanded memory window that is as big as the largest application program you want to run concurrently with other applications. Otherwise, it is not possible to switch tasks fast enough to perform multitasking efficiently. If you have an Above Board-type board, you will be able to swap tasks, but task execution for a background process will be suspended. True multitasking is possible with EEMS-type boards, and processes will be able to run in the background.

In addition, some of the expanded memory emulators like Qualitas's 386 to the Max also have the ability to map into the conventional memory area. Therefore, with a product like this, you can also do true multitasking. None of the software-only emulators can perform multitasking. Programs like 386 to the Max, although they are not expanded memory hardware boards, do use hardware paging registers to perform context switching. In this case, the paging registers of the 80386 chip are used.

The Last Word

What can you expect in the way of new hardware and software developments as a result of EMS 4.0? Some of the immediate benefits will be massive RAM disks, print-spool buffers, Lotus 1-2-3 spreadsheets, AutoCAD drawings, and more memory for everyone involved. As more and more memory-resident utilities make use of EMS, you will be able to keep many of your favorite pop-up utilities available simultaneously.

Although EMS 4.0 is a dramatic improvement over EMS 3.2, many of the new developments you will be seeing are not directly related to the 4.0 specification itself (the driver). They are the result of the standardization of both the new hardware and software designed to support EMS 4.0. Cooperation between the major players in the microcomputer market in regard to EMS 4.0 has resulted in better and safer development tools for the programmer, which can only lead to better and safer applications for the user. ■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John Poplett and Rob Kurver

The DSI Transputer Development System

Definicon Systems' new Transputer coprocessor board puts concurrency in your IBM PC

New-generation microprocessors like the 80386 and the 68020 have brought the power of a minicomputer onto the desktop. Yet even this power is inadequate for software designers who are working with applications that run mainly on supercomputers, such as ray tracing and other solid modeling graphics.

Increased microcomputing power is emerging from two main areas of technological development: high-speed reduced-instruction-set computer (RISC) technology and parallel processing. RISC technology offers the promise of microcomputer systems that approach today's supercomputers in performance, yet it requires little change in the way current software is developed. Parallel processing offers the promise of systems whose computing power is limited only by the resources of the system designer and the ingenuity of the programmer.

BYTE has arranged with Definicon Systems to offer BYTE subscribers the TG2 multiprocessor board and TCC, a parallel C compiler, at a special introductory price (see the text box on page 250). The board and compiler let you develop software in parallel at a cost lower than previously possible. This board contains two 32-bit INMOS Transputers, a host interface, and a television-quality graphics section on a single IBM PC expansion bus card.

The INMOS T414 Transputer

The idea of yoking together a number of processors in parallel to perform a computationally demanding task is as conceptually simple as it is difficult to implement. The appeal of this approach is that, in theory, you can add more processors to such a system as computational workloads increase. The difficulty is that conventional microprocessor technology makes little, if any, provision for the fundamental requirement of parallel processing: a mechanism for interprocess communications.

The INMOS Transputer was designed for parallel processing; facilities for interprocess communications are embedded in the chip's silicon. In addition to a 32-bit microprocessor, a dynamic RAM (DRAM) memory controller, and 2K bytes of 50-nanosecond on-chip RAM, the Transputer implements four high-speed direct-memory-access engines—dubbed "links" by INMOS—for serial data communication with neighboring Transputers. Transputer links comprise two unidirectional channels each. The links can transfer data in both directions at a rate of up to 20 megabits per second. The four hardware links and the microprocessor can independently access memory simultaneously; this is accomplished with minimal loss in processor throughput.

The links implement a communication protocol in hardware. The Transputer communicates by sending data bytes down the output channel of a link, framing each data byte with a start and stop bit. Once it has sent a data byte, the Transputer waits until it receives an acknowledge message on the input channel of the link. Programmers have access to these hardware links via instructions in the instruction set of the Transputer's microprocessor.

The Transputer supports multitasking in hardware, but it is more instructive, with respect to the Transputer's design, to regard multitasking as virtual concurrency. In a Transputer network, parallel processes may be physically concurrent (running on separate Transputers) or virtually concurrent (multitasking on the same Transputer). In practice, physically concurrent and virtually concurrent processes most likely will be running on a Transputer network.

The Transputer's multitasking capability makes it possible for you to write a concurrent program for a network of Transputers even when the number of computing nodes in the network is unknown or may vary. You could design a program embodying, say, twelve parallel processes to function the same on a single Transputer as it would on a network of two, three, four, or twelve Transputers. Programs designed in this manner can gain an almost linear increase in execution speed as you add Transputers to the network.

TCC, A Parallel C Compiler

TCC is a superset of the Kernighan and Ritchie definition of C that incorporates extensions to support concurrent programming on a network of Transputers. The TCC package consists of a compiler, an assembler, a linker, and a run-time library.

The TCC's run-time library closely follows the emerging ANSI run-time standard. It accomplishes access to the host PC's file system via level-two file I/O functions, such as `fopen()`, `fread()`, `fwrite()`, `getc()`, and so on. Functions for low-level access to the host (e.g., `bdos()` and `sysint()`) and functions for sending and receiving message packets supplement the standard run time.

You can control all the Transputer's devices directly, including those that support concurrency, by the MPU's microcode. The Transputer's instruction set has instructions to start up processes, to start up interprocess communications, to select a process's priority, and to cause a process to wait on an event. Standard high-level languages (HLLs), including C, Pascal, and

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FORTRAN, lack any formal constructs that correspond to these operations. Consequently, conventional language implementations would never access the Transputer's concurrent programming resources.

To get at the Transputer's parallel processing capabilities, you have a few options. You could provide a subroutine or function library to extend the language. Another possibility is a distributed operating system or kernel that manages all the parallel aspects of a system through system calls. The option we took in the development of TCC was to extend the definition of the C language. These extensions include the `channel` data type, the `par` construct, the `alt` construct, and the pseudovariable `timer`.

Extending the language definition has the advantage of efficiency, since the compiler produces in-line code (instead of a function or system call) whenever a programmer uses one of these parallel constructs. The efficiency gained by this approach is similar to that gained by a compiler that generates in-line code for a floating-point unit rather than calling floating-point functions.

Parallel Extensions

Parallel extensions include the following:

• *The* `channel` *data type and interprocess communications.* TCC's `channel` data type supplies the mechanism for synchronized process-to-process communications. The programmer uses `channel` variables to send data entities between two processes. These processes may reside on the same Transputer or on two different Transputers connected by a link. The `channel` data type conducts interprocess communications with equal facility in either instance. `Channel` variables behave in a manner that is consistent with the C language. They accept the cast op-

The TG2 Multiprocessor Board

The TG2 uses two 15-MHz INMOS T414 Transputers. Each Transputer can address 1 megabyte of supplied DRAM in addition to its 2K bytes of internal memory. You can upgrade the second section of the TG2 to accommodate 4 megabytes of DRAM.

The graphics section provides a bit-mapped display of up to 512 by 512 pixels with 24 bits of color per pixel. It can display over 16 million colors simultaneously on low-cost multisync monitors. The display system operates independently of the host PC's display. The on-board Texas Instruments 34061 video RAM controller allows complete programmability of the displayed pixel count and the sync rates (e.g., for PAL operation).

The Transputer board communicates with the host PC for console I/O and other system service requests via a Transputer hardware link. To ease the programming task, the TG2's host interface causes the host to appear as though it were another Transputer on the network.

The TG2 provides a row of pin headers for interconnection of Transputer links, affording the developer complete control over network topologies. You can arrange the Transputers in two-dimensional grids, binary trees, hypercubes, or systolic arrays. You can network and run multiple TG2s from the host PC, and larger Transputer networks are possible with the use of a PC expansion chassis. The size of the Transputer network is limited only by the number of available expansion slots and power supplies.

You can also use the TG2 with Definicon's T4 multiprocessor board. The T4 omits the graphics section to provide four Transputer sections on a single PC expansion bus card.

A Transputer Macro Assembler

Definicon supplies each TG2 with a full-featured macro assembler, TMAC, to support Transputer program development at the assembly language level. TMAC recognizes the complete instruction set, as published by INMOS, for the T414 and provides extensive pseudo-op codes to facilitate the programming task. These pseudo-op codes allow the programmer to define bytes, words, macros, and constants; to align code and data in memory; to toggle listings; and to include files.

Product Information

Definicon Systems will provide the DSI-TG2 Transputer graphics board and the TCC development system at the following special prices for BYTE readers. Definicon has not allowed any margin for accounting overhead, so no purchase orders can be accepted for these products. At these prices, documentation is supplied on floppy disk. (You can order a printed copy of the documentation at additional cost.)

To order, contact Definicon Systems (1100 Business Center Circle, Newbury Park, CA 90320, (805) 499-0652). Terms of payment are Visa, MasterCard, or American Express only. There is a 30-day, no-questions-asked, money-back guarantee. Goods must be returned in "as new" condition in original packaging for full credit.

Software support available is limited to diagnosis and correction of your software problem. The TG2 board has been tested in machines compatible with the IBM XT and AT. If it doesn't work in yours, Definicon reserves the right to either correct the problem (if it pertains to the DSI-TG2) or refund your money.

The DSI-TG2 will operate in a system with floppy disks, but you'll need a hard disk for meaningful program development.

The DSI-TG2 with a single Transputer section costs $945. One Transputer section consists of 1 megabyte of dynamic RAM and one 15-MHz T414; a host interface section; MS-DOS interface software; and macro assembler—assembled and tested.

The DSI-TG2 with two Transputer sections costs $1595. Two Transputer sections consist of 1 megabyte of DRAM and one 15-MHz T414 per section; a host interface section; MS-DOS interface software; and macro assembler—assembled and tested.

The DSI-TG2 with two Transputer sections and graphics costs $1995. Two Transputer sections consist of 1 megabyte of DRAM and one 15-MHz T414 per section; one high-definition graphics section (512 by 512 pixels, 24 bits per pixel); multisync monitor output; a host interface section; MS-DOS interface software; and macro assembler—assembled and tested.

The TCC "Parallel" Development System consists of a TCC compiler, assembler, and linker for $395. The Kernighan and Ritchie definition C compiler has extensions for parallel programming, in addition to many Unix and ANSI extensions.

TG2 and TCC documentation costs $35 and includes typeset, printed material for the DSI-TG2 Transputer board; TMAC, the Transputer macro assembler; and the TCC Development System.

erator, the sizeof operator, and type checking.

C's assignment statement is used with channel variables to send and receive data between two processes. When data is "assigned" to a channel variable within a process, the process attempts to send the data; conversely, when a channel variable assigns its contents to a data variable, the process attempts to read data via the channel into the data variable. Communication is synchronized; it occurs only when two processes become ready to communicate via a shared channel. The Transputer automatically deschedules a process that is waiting to communicate. The following code fragment illustrates how a process might send a message to a host system:

```
static char *msg = "hello world!";
char *ptr = msg;
channel *host = (channel*)0x80000000; /*
          host link output */

while(*ptr)
  *host = *ptr++;
```

Whereas this code fragment illustrates how a program might send a character string down a link, the channel data type supports the transmission of a variety of data types, including floats, integers, arrays, and structures. Here is an example using nonpointer channel variables:

```
channel Comm01;

Calc01() {
     double result;
     for(;;) {
          ... code ....  /* a nasty
          calculation here */
     Comm01 = result;
     }
}
IOProc01() {
     double result;
     for(;;) {
     result = Comm01;
     printf("result: %g\n", result);
     }
}
```

In this example, Calc01 and IOProc01 run as concurrent processes. IOProc01 waits to receive result over the channel Comm01. Upon receipt of result, IOProc01 displays the value on standard output; Calc01 is released to start its next calculation. Pending input from Calc01, the Transputer deschedules IOProc01 so that microprocessor unit (MPU) cycles are not wasted on an idle process.

• *The* par *construct*. This starts up (spawns) processes on a Transputer. It resembles a compound statement in C:

```
void proc01(), proc02(), proc03();

     ... code ....

     par {
          proc01();
          proc02();
          proc03();
     }

     ... code ....
```

This example starts three separate processes to call each of three functions. The processes terminate when the functions return. The parent process waits for the three processes to terminate and then resumes execution with the code following the par statement. Processes started with the par construct each have their own stack (or "workspace," as it is known in Transputer nomenclature). Workspace requirements are calculated by the compiler at compile time and dynamically allocated at run time.

• *The* timer *pseudovariable*. The timer pseudovariable provides the programmer with access to the Transputer's on-chip timer. By means of this pseudovariable, you can read the hardware timer or write to it almost as if you were reading or assigning a value from an integer variable:

```
#include <time.h>
     (int) timer = 0;

     .... code .... /* your favorite
               benchmark here */

     printf("ELAPSED TIME IN SECONDS %ld\n",
               timer/CLK_TCK);
```

In this example, the assignment to timer is prefixed with an integer cast operator. The cast operator informs the compiler to initialize the hardware timer only. You can deschedule a process for a specific interval with the use of the timer pseudovariable:

```
timer += 1000; /* sleep for a thousand
          clock ticks */
```

• *The* alt *construct*. The alt construct provides a software mechanism whereby a process may arbitrate between events. With the alt construct, a process can test the readiness of any of several events, selecting the first event to become ready. An event may be a ready channel, a ready timer, or a Boolean true condition. Each component of an alt construct (i.e., each alternative) uses the keyword guard.

Its syntax and function are not unlike the C switch statement:

```
typedef Boolean int;
channel Comm01, Comm02;
int Result;
Boolean NoTimeOut = FALSE;

... code ....

TimeOutBegin:
alt {
     guard NoTimeOut: break;  /* boolean
          event */
     guard &Comm01: Result = Comm01;
          break; /* channel event */
     guard &Comm02: Result = Comm02;
          break; /* channel event */
     guard timer += 1000; break; /*
          timer event */
     default: goto TimeOutBegin; /* no
          event ready just yet */
}
```

This code fragment illustrates how you can use the alt construct to multiplex channels and to time-out a process in the event of a communications failure. This statement evaluates three alternatives: It checks for the readiness of the Boolean flag TimeOut, the readiness of channels Comm01 and Comm02, or the readiness of the timer. Alternatives are evaluated in the same order as they are written: from top to bottom. Thus, if two events should become ready simultaneously, the first in order is selected. The first alternative tests the status of the Boolean variable NoTimeOut. If true, the alternative is skipped altogether. The next two

continued

The network booter (NB) acts as a virus, spreading itself and a program throughout a Transputer network. It is limited to a daisy-chain topology; for other topologies, you would have to add more logic into NB.

alternatives check for pending input on one of two channels. Should either channel become ready, an input is performed and the alt statement terminates. (In this instance, input from two processes are multiplexed; in an actual application, an I/O routing process might funnel the output of a number of processes into a single channel.) The third alternative will cause a time-out if either of the two channels should fail to become ready within a specific time interval. Our example merely breaks out of the alt statement on a time-out; you could use this alternative to initiate a recovery strategy or to print an error message.

• *The* #pragma *macro preprocessor directive.* TCC provides a number of #pragma preprocessor directives to give the programmer greater control over program execution. These directives include #pragma par, #pragma seq, #pragma fast, #pragma slow, and #pragma stack.

The par and seq directives allow you to control the compilation mode of a C module. You can also select either mode from the command line upon compiler invocation. In the parallel compilation mode, functions call a workspace allocator to a reserve space for local variables. This dynamic allocation of process workspaces ensures that recursion is possible even when multiple processes are executing concurrently. In sequential compilation mode, a single workspace is allocated at program startup. This workspace behaves identically to a stack on a conventional microprocessor. You use the sequential mode when a Transputer program consists of a single process, obviating the overhead of dynamic workspace allocation. You can use sequential mode when single-process programs are run on multiple Transputers.

The stack directive instructs the compiler to reserve a specific amount of memory for a given function or set of functions. This directive takes a hexadecimal value as an argument. It typically prefaces a function definition:

```
# pragma stack 8000  /* reserve a 32Kbyte
                         stack */
main(argc, argv)
int argc; char **argv;
{
        ...code...
}
```

The fast and slow directives are used in conjunction with the parallel compilation mode. They provide control over the workspace allocator. Functions prefaced by the fast directive will first try to obtain their workspaces from the Transputer's on-chip RAM, while functions prefaced by the slow directive will receive their workspaces from external memory.

Run-Time Support for Parallel Processing

The TCC run time provides additional support for the Transputer's parallel processing capabilities, particularly in instances where the compiler's language extensions are ill suited.

The functions msgsend() and msgrcv() send and receive data packets of arbitrary lengths across channels. Channel assignments work only with data entities whose size is known to the compiler. Consequently, you will often use these functions to send and receive buffers:

```
channel Comm01;
Proc01() {
      static char *msg = "hello
          world!\n");
      Comm01 = strlen(msg);
      msgsend(&Comm01, msg, strlen(msg));
}
Proc02() {
      char str[MAXSTRLEN];
      int length;
      length = Comm01;
      msgrcv(str, &Comm01, length);
      puts(str);
}
```

The function startp() takes a function address as a parameter and starts the function as a separate process. A programmer can use startp(), albeit with caution, to run multiple processes in a program compiled in sequential mode.

The function resetch() initializes a channel variable, taking the address of a channel variable as a parameter. (You must initialize channel variables before you can use them.)

The two functions stpri() and ldpri() pertain to process priority levels, of which, on the Transputer, there are two: high and low. The function stpri() sets the priority status of the process that calls it; ldpri() returns the priority status of the calling process. A high-priority process will always execute in preference to a low-priority process. However, the Transputer will deschedule a high priority if that process is waiting to communicate or is waiting for a timer to become ready. The Transputer will then grant time slices to any extant low-priority processes. Should the high-priority process become ready to run again, the low-priority processes will be interrupted.

Programming a Transputer Network with TCC

On a single Transputer, we can start up a number of processes using TCC's par construct or the run-time startp() function. Running multiple processes on a single Transputer compares to the kind of multitasking that operating systems such as Unix perform. In this case, we do not have true concurrency but, rather, virtual concurrency. You can achieve true concurrency on a single Transputer with programs that make use of channel I/O. In such a case, it is possible to employ one or more of the Transputer's links even as the MPU is executing code.

The link facilities of the Transputer make it possible for you to use various schemes of interconnection between multiple Transputers in a network. These interconnection schemes are known as "topologies."

Topology types include two-dimensional arrays, systolic arrays, hypercubes, and trees. Strategies in implementing or choosing a Transputer topology may involve minimizing the distance of link paths between Transputer nodes for efficiency and redundancy of link paths for reliability. In the programming example that follows, we chose to make a daisy chain of Transputer nodes; this topology has the virtue of simplicity.

Concurrency with Multiple Transputers

Two expedient techniques for concurrent programming on a Transputer network are pipelining and the FARM architecture.

Pipelining sets up stages of a program, with each stage lodged on a separate Transputer. The first stage sends its output to the second stage, the second to the third, and so on. A compiler is a good example of a program that stands to benefit from pipelining. A pipelined compiler, running on a Transputer network, might run its preprocessor in the first stage, the lexical analyzer and parser in the second stage, the code generator in the third, and an output process, which resolves a binary image to a specific link format, in the fourth. Pipelining transforms a program from a single sequential process with multiple phases to an ordered set of concurrent processes. In addition to the performance benefit, a pipelined program imposes the kind of modular design on a program that lends itself to ease of maintenance and team development efforts.

The FARM architecture is implemented by identifying one or more points in a program where a calculation task iterates through a wide body of data. These calculation tasks are then coded as individual processes and replicated on each node in a Transputer network. Typically, a message passer process or processes are replicated on the network along with these calculation processes.

The following represents a simple form for a calculation process on a FARM:

1. Wait for input on a given channel or link.
2. Input the data.
3. Perform the calculation on the data.
4. Wait for output on a given channel.
5. Output the data.
6. Repeat.

The program TDHRY.C is a version of the well-known Dhrystone benchmark modified to run in parallel on a Transputer network. [Editor's note: *TDHRY.C is available for uploading from BYTEnet and BIX. The author has also provided another example program—PWC.C, a word-counting program—for uploading. It and its documentation, PWC.DOC, are available on BYTEnet and BIX.*] It uses a rudimentary FARM architecture. Underpinning the TDHRY.C program is a network booter, NB.LIB, or NB for short. NB performs the fundamental task of booting TDHRY.C on multiple Transputers. The operation of NB, as shown in the list below, is fairly straightforward:

1. A prebooter reads NB into Transputer memory.
2. NB reconstructs a clone image of itself and the prebooter in Transputer memory.
3. Each of the nonboot links is tested for the presence of a Transputer on the other end.
4. The status of each of the four links, including the boot link, is recorded in an array.
5. NB uploads a copy of itself (its clone image) to each of the active nonboot links.
6. NB begins to read in the program proper. As it reads in the program, copies are sent to all the active nonboot links (those that received a copy of NB). Any requisite code relocation, data initialization, and so on, is done at this time.
7. NB reads in the command-line argument count and the argument vector from its boot link. To each of the active nonboot links NB sends out a null argument count. (Thus, only the program on the root Transputer has a non-null argument count.)
8. NB sets up a stack for the program and calls `main()`.

NB acts as a virus, spreading itself and a program throughout a Transputer network. The original copy of the program (that lodged on the root Transputer) differs from its clones in one respect: All clones have a null argument count, while the root program has an argument count of at least one (for `argv[0]`). `Argv[0]`, of course, is a pointer to the program's name. The clone copies of the program are (fittingly) nameless.

NB is limited to a daisy-chain topology; it assumes only one connection between any two Transputers. For other topologies, we would have to incorporate additional logic into NB; namely, NB would have to have a strategy to recognize an active link that has already been booted by another Transputer.

With NB in place, the modifications to the Dhrystone benchmark are slight. However, it is necessary to code in different logic paths that depend on whether the program is a clone copy or the original copy on the root Transputer. The root Transputer is charged with displaying the benchmark results on the console, since it is the only copy of the program with direct access to the host system.

The following piece of code is the initialization code at the start of `main()`:

```
main(argc, argv, LinkArray)
int argc;
char *argv[];
channel *LinkArray[];
{
        int i, NoOfTxxs = 1;
        if(argc > 1) {          /* if root copy
                of DHRY.C */
                NoOfTxxs    =    atoi(argv[1]);
                /*  get # of transpnters */
        if(argc == 0) /* if clone */
          NoOfTxxs = *_fromhost; /* get # of
                TXXs */
        for(i = 0; i < 4; i++) {   /* for
                total # of links */
                channel *ChanPtr;
                if((ChanPtr  =  LinkArray[i])
                != 0) /* if  booted link */
                        *ChanPtr = NoOfTxxs;
                /* send # of TXXs */
        }
        Proc0(argc, NoOfTxxs, LinkArray);  /*
                call Proc0 */
        exit(0); /* all done */
}
```

The root copy of the program determines, from a value passed on the command line, the number of Transputers in the network. Clone copies, lacking command-line arguments, must determine the number of Transputers by fetching it from their boot link. Then for each active link, the program—be it a clone or the root copy—passes along `NoOfTxxs`. Eventually, all copies of TDHRY.C executing in the network are informed of the total number of Transputers in the network.

The next point of interest in TDHRY.C occurs in `Proc0()`:

```
loops = LOOPS/NoOfTxxs; /* adjust
        iteration count */
```

Here, the constant LOOPS is replaced by the variable `loops`, which is equivalent to LOOPS divided by the total number of Transputers in the network. The main iteration loop of the benchmark replaces the constant LOOP with the variable. Thus, a single Transputer running the benchmark will iterate to the full value of LOOP; two Transputers running the benchmark will each iterate to LOOP / 2; four Transputers, to LOOP / 4; and so on. In any case, the number of total iterations performed on the network will equal LOOP, and the results, save the overall execution time, will be the same.

Once the main iteration loop of the program completes, each copy of the program on the network calculates its execution time, collects the execution times of any Transputers it might have itself booted, and forwards this value to the Transputer that

continued

booted it. Eventually, the aggregate execution time is collected by the root copy of the program and displayed on the console:

```
if(NoOfTxxs > 1) {
        for(i = 0; i < 4; i++) {
                channel *ChanPtr;
                if((ChanPtr =
       LinkArray[i]) != 0) {
                         ChanPtr =
       ChanPtr&0x10;
                         benchtime +=
       *ChanPtr;
                }
        }
}
if(IsRoot) {
        printf("Dhrystone(%s) time
       for %ld passes = %ld\r\n",
                Version,
                         (long) LOOPS,
       benchtime);
        printf("This machine
       benchmarks at %ld
       dhrystones/second\r\n",
                ((long) LOOPS) /
       benchtime);
} else {
        *_tohost = benchtime;
}
```

Theoretically, the parallel Dhrystone should yield almost linear increases in performance as Transputers are added to the network. Communications overhead will, of course, preclude the possibility of strict linear increases. Running TDHRY.C on the TG2 board confirms the theory: On a single 20-MHz Transputer, TDHRY.C achieves about 4500 Dhrystones. Two Transputers boost the execution time to about 8600 Dhrystones—not quite a factor of 2, but close.

Conclusion

The INMOS Transputer's on-chip support for parallel processing make it an efficient parallel-processing engine. The TG2, TCC, and the TMAC macro assembler combined form a cost-effective parallel-processing development system for PC users.

TCC defines extensions to the C language that a high-level language needs to harness the potential of the Transputer in a multiprocessor network. TMAC offers similar capabilities for the assembly language programmer. With these tools, software developers can design programs for Transputer networks of any size and with almost unlimited performance potential. ■

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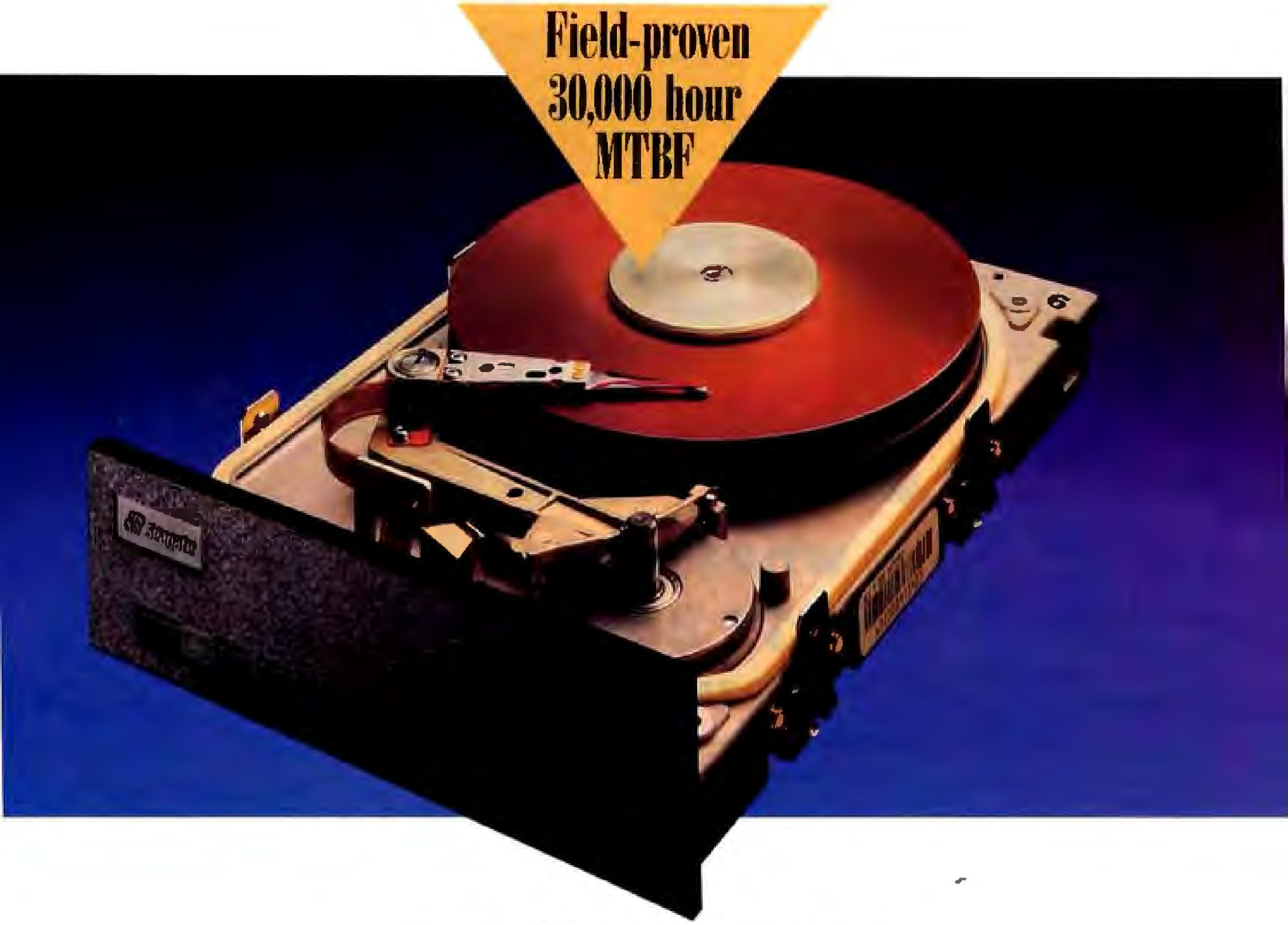

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Part 2: EPROMs and Compilers

Steve Ciarcia

The BCC180 Multitasking Controller

Using the Hitachi HD64180 CPU, Steve's project is a multitasking single-board computer/controller

In last month's article, I introduced the BCC180 multitasking controller by describing the basic hardware and alluding to the power of its ROM-resident multitasking software. This month, I'll finish the discussion of the BCC180 hardware and introduce the BASIC-180 multitasking compiler in more detail.

The BCC180 Auxiliary EPROM Programmer Board

An attractive feature of the BCC52 (see the August 1985 Circuit Cellar) is its on-board EPROM programming capability. Using the BCC52 and a terminal, you can write a program, debug it, and burn it into the final EPROM.

Since the 8052 chip used on the BCC52 is really a full microcomputer (as opposed to a general-purpose microprocessor), it is capable of programming EPROMs connected to the processor's address and data lines. Unfortunately, the HD64180 used on the BCC180 needs additional circuitry to tailor its function to something as specialized as programming EPROMs.

While I could have added this circuitry and exactly duplicated the stand-alone utility of the BCC52, I felt that such an infrequently used option would make the final board overly large and more expensive. Instead, as a compromise of essential flexibility and price/performance, I decided to put the EPROM programming circuitry on a small daughterboard that you use only as needed (see figure 1).

The daughterboard plugs into the J5 and J6 8255 peripheral interface adapter (PIA) parallel-port connectors on the BCC180 (refer to last month's circuit diagram). There are six parallel ports: One is connected to the EPROM's data bus and is used to read data from and write data to the EPROM; two more ports provide the EPROM with an address; 2 bits from a fourth port control the EPROM's CE\ and OE\ lines, and two more bits from that port control power to the EPROM and control the programming voltages; a fifth port reads the daughterboard's identity code.

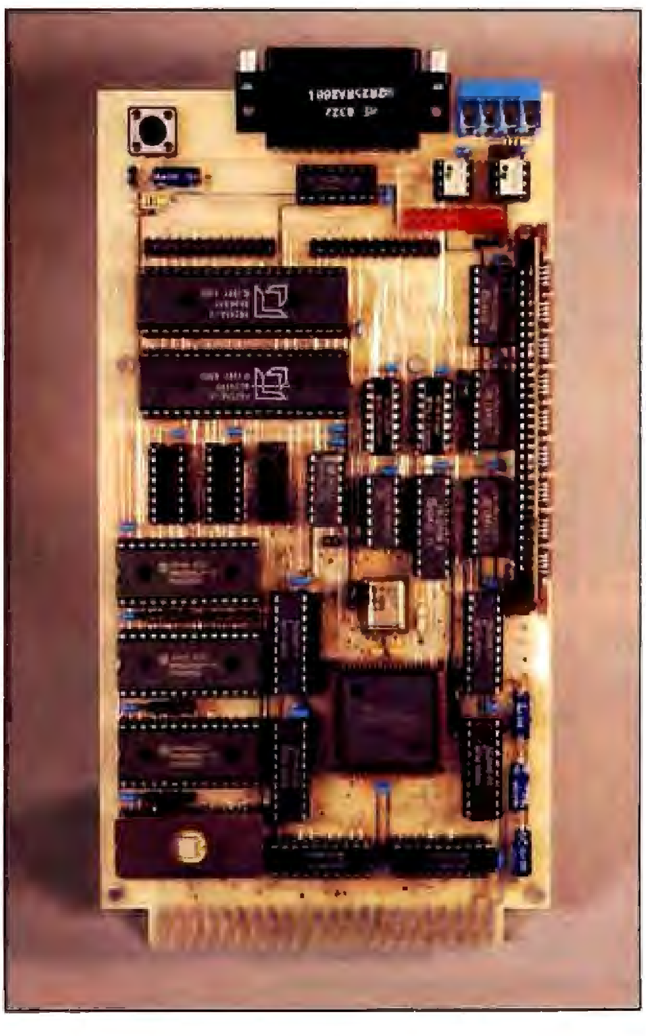

Photo 1: *The BCC180 computer/controller.*

The first problem to overcome when designing an EPROM programmer is where to get the necessary programming voltages. The BCC180 needs +6 volts and +12.5 V to perform fast programming of 27256 EPROMs (see my October 1986 article for information on "fast" and regular EPROM programming techniques).

Instead of using an external +21-V power supply, as I did on the BCC52, this time I had the real estate and incentive (performance usually takes priority over cost on optional boards) to do the job more completely.

The BCC180 EPROM programmer requires only +5 V for its operation (see figure 1). It uses a 78S40 switching regulator to step +5 V up to

continued

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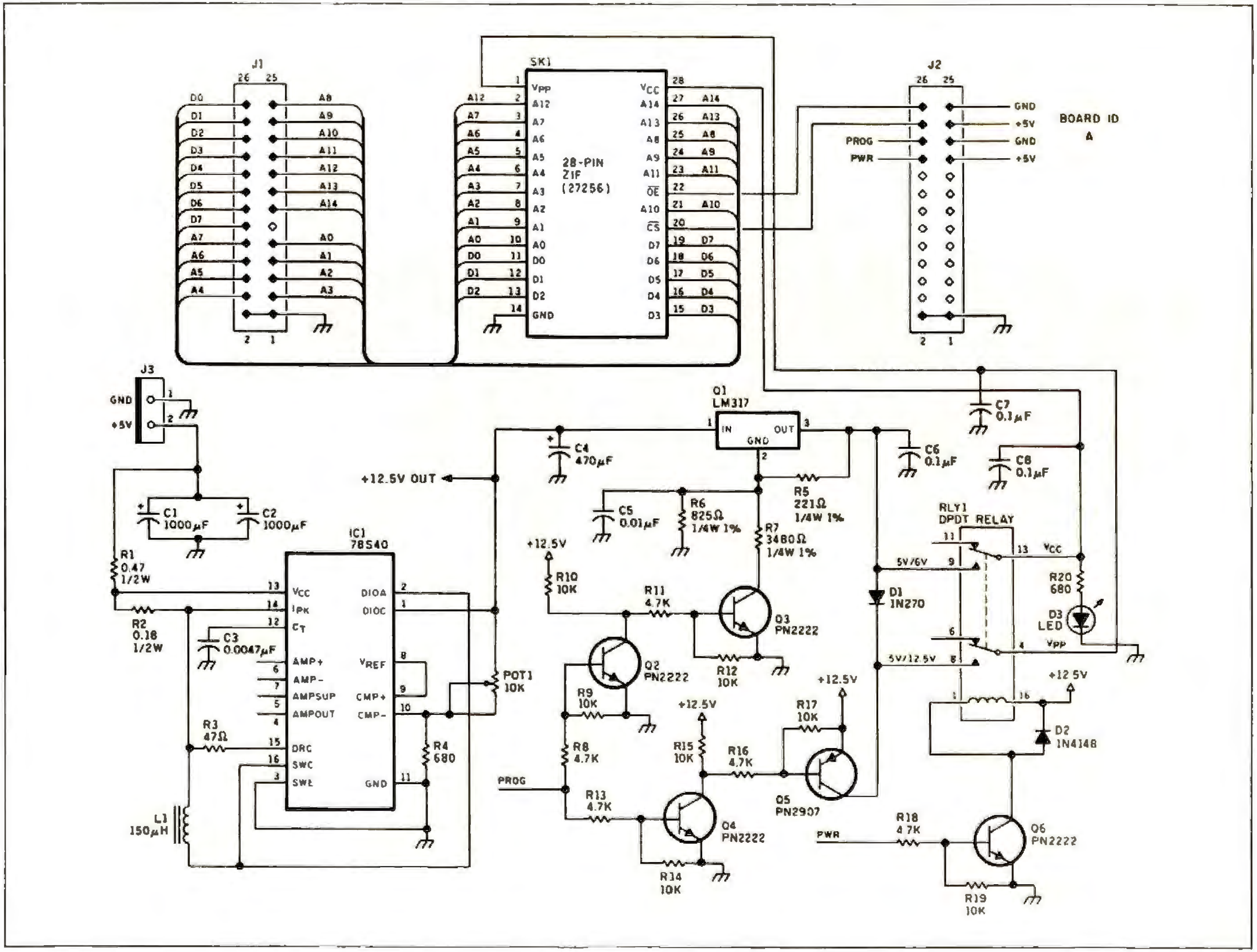

Figure 1: Schematic for the BCC180's EPROM programming board.

+12.5 V and regulates +6 V from it.

The 78S40 is a general-purpose switching regulator. It is capable of stepping a voltage up to a higher voltage (+5 V to +12 V), stepping a voltage down to a lower one (+12 V to +5 V), or inverting a voltage to a negative voltage (+12 V to −5 V). I wired it up to convert from +5 V to +12.5 V. A variable resistor on its output fine-tunes the final output voltage.

Once we have the +12.5-V V_{pp} supply, how do we switch the voltages on V_{pp} and V_{cc} between 0 V, +5 V for normal operation, and +12.5 V or +6 V for programming? (The 0 V is necessary for safe loading and unloading of the EPROM in the zero-insertion-force [ZIF] socket.) The easiest way to force V_{pp} and V_{cc} to 0 V is simply to disconnect both pins from the power supply. I used a double-pole, double-throw (DPDT) relay controlled by a bit on the BCC180's parallel ports (PWR) to accomplish this. When the BCC180 is reset, PWR floats low (due to the pull-down resistor, R19) and power to the EPROM stays disconnected. When PWR is set high, transistor Q6 turns on and energizes the relay coil, pulling in the relay and applying power to the EPROM.

The method I used to generate 6 V and to switch the V_{cc} line between +5 V and +6 V is reminiscent of my serial EPROM programmer. The LM317 is an adjustable voltage regulator whose output voltage depends on the value of the feedback resistor (R5) connected between the output and the control input and a second resistor from the control input to ground.

When transistor Q3 turns off, the total resistance from the control input to ground is 825 ohms. This sets the LM317 output to +6 V. When Q3 turns on, the total resistance becomes 667 ohms, causing the output to be regulated to +5 V.

Upon reset, the program voltage control line coming from the BCC180 (PROG) floats low, due to the pull-down resistors R9 and R14. Transistor Q2 stays turned off, so the base of Q3 gets pulled high to +12.5 V. This, in turn, turns Q3 on, connecting R7 to ground. With R6 and R7 in parallel, the LM317 will output +5 V to V_{cc}. When PROG is pulled high, indicating that programming is to begin, Q2 is turned on and forces Q3 to turn off. With Q3 turned off, R7 is removed from the circuit, and the LM317's output voltage (and V_{cc}) becomes +6 V.

To control the switch between +5 V and +12.5 V on the V_{pp} line, I used a slightly different technique. When PROG is low, Q4 is off, allowing the base of Q5 to be pulled to +12.5 V. Q5 is a positive-negative-positive (PNP) transistor, so the high voltage on its base keeps it turned off and its collector floats.

Since we want both V_{cc} and V_{pp} to be +5 V when PROG is low, we can steal +5 V from the circuit described above using a low-drop germanium diode. In normal operation, V_{pp} draws less than 5 milliamperes, so the drop across the diode is only 200 millivolts or so.

When PROG goes high, indicating that programming is to begin, the system turns on Q4, pulling Q5's base to ground. Q5 turns on and allows +12.5 V to get through to the V_{pp} line. On the other side of the diode, V_{cc} goes only to +6 V, so the diode is reverse-biased and stops conducting, effectively isolating V_{cc} from the high voltage on V_{pp}.

The final feature on the programming daughterboard is a board ID number. Right now, since the BCC180 uses only 27256s, that's all this programmer board is designed to handle. But because we'll no doubt have other daughterboards, there is a unique ID number (read via a few bits on port 6) assigned to each daughterboard. This will allow intelligent software to check what board is installed.

In Search of Appropriate Software

Of course, no project these days is just hardware. Like any computer, the BCC180 is not very useful without software. If it were a disk-based system like the SB180, we would need only a BIOS. However, since it is a stand-alone computer, it requires either a cross-development environment or an embedded language with its own operating system.

Before defining what software is required for the BCC180, we should look at the board's typical applications. It is not designed as another generic computer for word processing, spreadsheets, or games. The BCC180 is for embedded applications where it may not be particularly obvious that a computer is part of the system.

For example, a factory-control system will typically use a number of computers distributed around the building. A single BCC180 might control one local process and then be linked by a serial line to a master control computer. Each remote processor independently runs a ROM-resident program directing that processor's activities.

The system's software must fulfill certain common requirements. First, it must start automatically on power-up and execute out of ROM without operator intervention day after day for years. Ideally, you should be able to develop code directly on the BCC180 and then burn it into the EPROM. You could develop larger applications on another computer with disks—like the SB180—then burn the programs into the EPROM and place them on the BCC180.

Second, the software should take advantage of the extended memory of the 64180. Part of the attraction of 16-bit microprocessors is their large memory space, but, in real-time process control applications, an 8-bit computer will often run much faster than a 16-bit machine. The 64180 overcomes the 64K-byte memory barrier by incorporating a memory management unit (MMU) on the chip. The BCC180 has 384K bytes of RAM and EPROM on-board; the software must be able to use this.

Third, the software must be *fast*. Many real-time applications must respond to interrupts or other external events in milliseconds. The BCC180's supporting software must generate code that executes quickly, so that the system won't miss these events.

Finally, while multitasking is only now becoming common in the personal computer world, it has long been an important part of real-time systems. I dictated from the very beginning that any language for the BCC180 must implement multitasking.

Fortunately, I didn't have to start from scratch in finding this "perfect" software. Softaid created a custom-tailored operating system and language for the BCC180 by modifying its MT-BASIC compiler. The result was BASIC-180, which is a comprehensive BASIC specifically designed to meet the needs of the process control industry. It has all the features engineers and programmers have come to expect, like multitasking, floating-point math, multiline user-defined functions, and windowing (see the text box on page 263).

Why Multitasking?

Multitasking is the process of running two or more activities on a single computer at (apparently) the same time. It is important to distinguish it from multiprocessing (or multiprogramming), which is the process of running several activities on several processors at the same time. Multitasking is also not the same thing as "multiuser." A multitasking system is often single-user, although all multiuser systems are multitasking.

We say "apparently" because a single CPU can execute only one instruction at a time. The system performs multitasking by switching the processor between two or more activities at a high rate of speed. If two activities are sharing one CPU, the computer might execute one for 0.01 second, then the other for 0.01 second, and then switch back to the first. Over the course of time, each activity gets 50 percent of the available computer time. If three activities are running, each gets 33 percent.

continued

Even a multimillion-dollar UNIVAC or IBM mainframe works this way. A hundred or more users might be connected to a single-processor machine. Each appears to have sole control of the computer. The CPU switches between users thousands of times per second, giving each one perhaps 0.001 compute-seconds at a time. The computer is so fast, and humans so slow by comparison, that the users don't notice that they are sharing the machine.

The building block of a multitasking program is the *task*. A task is one logical activity that runs as a whole and that competes for computer time with other tasks. On a large mainframe computer, each task might be a single user's program, or sophisticated users might partition their program into a number of tasks that don't necessarily have to run sequentially.

Since every task competes for computer time, we say that tasks execute "concurrently." A simple multitasking system might alternately run each task in order. For instance, a three-task program would execute task 1, then 2, then 3, then 1 again, in this order, forever.

Of course, computers are never this simple; in most multitasking systems, the time-critical tasks can be commanded to run more often than others. This implies that the tasks run asynchronously with respect to each other. In other words, we really don't know what task is executing at any given time or in what order they'll run. However, since a task is a logically complete processing element and does not depend on the results of other tasks, this isn't a problem.

Many programmers can't envision how one program can be broken into asynchronous, independent activities. A simple example is a low-cost digital thermometer using multiplexed LED displays. A multiplexed display must be constantly refreshed. Only one LED segment is actually turned on at any time, but each segment is cycled so quickly that to the eye, they all appear to be on. Although a hardware-refresh controller is usually used to control the display, a small system can dispense with the extra hardware by using software to control the refresh.

One task would take the data to be displayed and cycle the LED segments as required. Another task would read the thermistor, compute the temperature, and pass the reading to the refresh task for display. Note that each task is completely independent. Each one can run by itself and doesn't care about the others. The only intertask communication is the displayed temperature.

Interrupts: The Key Ingredient

All multitasking systems rely on one critical hardware component: a regular source of interrupts. Whenever an interrupt is detected, the CPU stops executing the current routine and branches to another section of code called an interrupt service routine (ISR). In a multitasking system, an interrupt is applied regularly (say, 100 times per second) to the CPU. Whenever the CPU detects this interrupt, the ISR associated with that interrupt suspends the execution of the current task, preserves the state of the machine at the time of the interrupt, and starts another task going.

This process is called context switching, since the current state, or context, of the machine is preserved before another task is started. Since the entire context of the interrupted task is saved, that task can be restarted exactly as if it had never stopped. In other words, the task itself has no idea it is being interrupted, suspended, and then eventually restarted.

The context-switching interrupt is called the "clock tic," since it resembles the regular tick of a clock. The faster the tics come, the more often each task executes. If a system with 20 tasks has a 20-Hz clock, each task will execute once per second.

It would seem that increasing the frequency of the tics only makes things better, but there is a catch-22. The context task-switching code requires a certain amount of time to decide which task to execute next and to prepare that task for execution. If interrupts come too quickly, the processor spends most of its time deciding what to do next and never actually gets to the task itself.

On most microcomputers, an interrupt rate of 60 Hz tends to work well. This is an ideal number for generating useful timing values, yet it is not so fast that too much time is taken up with task overhead. The 64180 processor includes two separate timers, each of which can be programmed to generate regular interrupts at virtually any rate. BASIC-180 programs timer 0 to

◀**Photo 2:** *The EPROM programmer daughterboard for the BCC180. An EPROM is shown inserted in the zero-insertion-force socket (upper right of board).*

Photo 3: *The EPROM programmer daughterboard (from photo 2) is shown here attached to the BCC180 computer/controller.* ▼

How Fast Is Fast?

BASIC-180 generates true native 64180 code. An intrinsic optimizer is automatically invoked with each compile to ensure fast, efficient code generation. Although BASIC-180 is not as fast as a good C compiler, it compares favorably with other compiled languages. For comparison's sake, we benchmarked it against the MS-DOS version of MTBASIC, GW-BASIC, and CP/M's MBASIC.

BASIC-180 was tested running at 9.216 MHz on a BCC180 board. MBASIC was tested on a 6.144-MHz SB180 board. The MS-DOS BASICs were executed on a 4.77-MHz IBM PC. Comparing the CP/M and MS-DOS BASICs is a little like comparing apples and oranges, but it gives a feel for the differences in speed.

The test program used was the Sieve of Eratosthenes originally described in the September 1981 BYTE. Times listed are for one iteration of the code (see table A).

BASIC-180 has a provision to drastically speed up execution of programs. If the NOERROR option is specified before compiling, BASIC-180 generates a smaller file that runs faster. NOERROR removes much of the run-time error checking, so it should be used only on debugged programs. For example, when NOERROR is specified, no tests are made to see if an array subscript exceeds its maximum allowable value. When the Sieve program was run with NOERROR, BASIC-180 ran in 2.1 seconds.

Table A: *Times in seconds for various compilers and interpreters to execute the Sieve program. See the text for a description of each language.*

Language	Time
BASIC-180 (compiler)	7.1
MS-DOS MTBASIC (compiler)	8.6
MS-DOS GWBASIC (interpreter)	101
CP/M MBASIC (interpreter)	141
Whitesmith's C (compiler)	1.6
Microsoft FORTRAN (compiler)	1.7
BDS C (compiler)	4.9

generate mode 2 (vectored) interrupts at a 60-Hz rate (tics are 16.67 ms apart).

BASIC-180's context switcher is started each time the timer interrupts. If a multitasking program is running, this interrupt causes the context switcher to start another task. In the software supplied with the BCC180, a 60-Hz internal interrupt clock results in under 5 percent context-switching overhead (it's less still if we use an external 60-Hz interrupt source).

Tasks can also be controlled by interrupts other than those generated by clock tics. In more sophisticated multitasking systems designed from the start for process control, like the BCC180, tasks can be configured to start on the receipt of an interrupt from an external push button or limit switch, for example (the BCC180 has four external interrupt inputs).

A World of Multitasking Opportunities

Applications for multitasking abound. All large process-control applications involve many tasks that must be handled concurrently. Take a steel mill, for example. The computer controlling a steel-rolling mill's production can't suspend operations when the operator enters data into a keyboard. One task should just handle the keyboard. Another can be assigned to reading steel thickness, generally by measuring the amount of absorption of gamma rays produced by a radioactive source like cesium or americium.

A third task could be responsible for controlling the mill's jack screws to alter the thickness of the steel being rolled. Another task could measure the steel's temperature and compute a correction to the thickness as a function of temperature (2200-degree steel is several percent thicker than room-temperature steel). Other tasks can perform calibrations of the electronics, display computed thickness values on various consoles, and provide financial and historical data on the steel being produced.

Multitasking on the BCC180

On the BCC180, BASIC-180 is both the high-level language and the operating system. It contains all the device drivers and all the multitasking control code. As is the case with an operating system, BASIC-180 provides the entire environment that is seen by the programmer.

Regular Circuit Cellar readers know that I often use BASIC for demonstrating projects. I've found that in the process-control industry, BASIC is the language of choice, too. Let's face it, BASIC is the lowest common denominator in programming languages. Everybody knows BASIC. The same cannot be said of any other language.

BASIC-180 includes a complete set of statements for controlling multitasking. All we have to do is write our multitasking BASIC program, and BASIC-180 will ensure that the tasks sequence properly.

In BASIC-180, all multitasking programs are divided into some number of tasks. A lead task, sometimes referred to as task 0, must always exist. The lead task is the main program. For multitasking to commence, the lead task must start at least one other task running. Let's look at a simple example program:

```
10 RUN 1,60
20 GOTO 20
30 TASK 1
40 PRINT "Task 1"
50 EXIT
```

Although obviously BASIC, this short program contains a number of unfamiliar statements. Lines 10 and 20 comprise the lead task, while lines 30, 40, and 50 define task 1. (Remember that a task is a logically distinct section of code that will be executed concurrently with other tasks.) Every task (except the lead task) starts with a TASK statement. This defines the start of the task and assigns a reference to the task for use by the other statements. In this case, the task is defined as task number 1.

Line 50, the EXIT statement, defines the termination of the task. Whenever an EXIT statement is executed, the task associated with that statement will be terminated.

Line 40 forms the body of the task. In this case, when task 1 runs, it will print Task 1 once and the task will terminate.

Line 10 is a RUN statement, not to be confused with the RUN command that starts a program executing in most BASICs. RUN always takes two arguments. The first argument is the number of the task to execute (in this case, task 1). The second argument is how often to execute that task.

continued

In any other BASIC, line 20 is a bizarre aberration. It is an infinite loop, so of course no other processing can go on. Not in BASIC-180! Task 1 and line 20 compete for computer time. Processing will be shared between the two activities.

When the program starts, the RUN statement kicks off task 1. It places task 1 in the ready for execution state. When the next tic is detected, task 1 will start running. Although task 1 is short and simple, it is unlikely that the Task 1 message will be printed in less than one tic of the clock. If it is in the middle of printing the message and another tic comes, the loop at line 20 will be executed for the duration of a tic (16.67 ms).

When another tic is detected, task 1 will resume from where it left off. The user will not be able to tell the task was interrupted. After the message is printed, task 1 will exit. When a task exits, it effectively dies and stops competing for processor time.

The second argument of the RUN command (in this case, line 60) tells the context switcher to restart task 1 sixty tics (1 second on the BCC180) after it exits. This is analogous to reincarnation. Although the EXIT statement makes the task die, it will be reborn after a certain period called the schedule interval.

Consider the following program:

```
10 RUN 1,60
20 GOTO 20
30 TASK 1
40 <code>
50 GOTO 40
```

In this case, <code> represents one or more BASIC statements that do whatever the task is responsible for. This case is similar to our previous example, except the task never dies; the GOTO at line 50 keeps the task active forever. It will continue to share time with the line 20 loop, but since an EXIT is never executed, the task never goes away. The reschedule interval in the RUN statement (line 60) is ignored.

The concept of scheduling is an important one in multitasking programs. One of the most important resources in real-time systems is processor time; if it is all used up, the processor will not be able to keep up with the real-world events it is responsible for monitoring.

Although a task that has nothing to do can idle by executing an empty FOR...NEXT loop, this is a terrible waste of computer time. It makes much more sense for the task to execute an EXIT and set a schedule interval so it will be born again when needed. Between the time a task executes the EXIT and the time it is reborn, it uses no processor time.

In the following program, three tasks execute concurrently. Task 1 integrates 10 reads of some asynchronous event. It assumes that some other task is filling variable T with data. Task 1 smooths the data passed in T, returning a filtered floating-point value in AD. Task 2 prints the value in AD once every 2 seconds. Task 3 fills T with data. (In this case, we use random numbers for the data.)

```
10 REAL AD
20 INTEGER T1,T,I
30 RUN 1,1
40 RUN 2,120
50 RUN 3,20
60 GOTO 60
100 TASK 1
110 FOR I=1 TO 10
120 T1=T1 + T
130 NEXT I
140 AD=T1 / 10.0
150 GOTO 110
200 TASK 2
```



```
210 PRINT AD
220 EXIT
300 TASK 3
310 T=RND
320 EXIT
```

This example shows that all variables in a BASIC-180 program are global. You can pass data between tasks through the variables. (Integers are all loaded and stored using 16-bit instructions. Since an interrupt can be processed only when an instruction is complete, integers are always stored intact. Floating-point numbers are loaded and stored only with interrupts disabled. BASIC-180 briefly disables the interrupts during these transfers to ensure that the variables will not be corrupted).

Let's look at a program that demonstrates Nyquist's theorem (also known as the sampling theorem). Nyquist said that in order to accurately represent a signal, you must digitize it at a rate of at least twice the highest frequency in the sample. Therefore, to accurately digitize 60-Hz AC, you should sample it at least 120 times per second. If a signal is sampled at too low a rate, the digitized signal may look like something altogether different from the original (an effect known as aliasing).

In the following program, task 1 generates a low-frequency sine wave. Task 2 samples it asynchronously, as would be the case if you constructed an analog-to-digital (A/D) converter to read the AC power's sine wave. You can specify the sample rate to task 2, which is simply how often the task is scheduled. A low number means a high sample rate, and an accurate representation of the sine wave is thus obtained. A large number will cause task 2 to run only occasionally, yielding a distorted picture of the sine wave.

```
100 INTEGER I,J,K,S
110 REAL A
115 I=0
190 PRINT : PRINT : PRINT : PRINT : PRINT
200 PRINT "Sampling Theory demonstration"
220 PRINT
230 PRINT "Enter the sampling rate (1 to
          1000) ";
240 INPUT S
300 RUN 1,20
310 RUN 2,S
330 GOTO 330
500 TASK 1
510 A=SIN(I)
520 I=I + 10
530 IF I < 360 THEN GOTO 550
540 I=0
550 EXIT
600 TASK 2
605 K=A * 30. + 35
610 FOR J=1 TO K
620 PRINT " ";
630 NEXT J
640 PRINT "*"
650 EXIT
```

BASIC-180 supports several other multitasking statements. These statements are designed to give you more control over the operation of each task.

The WAIT statement lets you manually suspend a task for any period of time. When a task issues a WAIT, that task no longer receives access to CPU time until the number of tics given as WAIT's argument have elapsed. WAIT is essentially a free delay mechanism, because the delay requires no CPU time to manage. WAIT takes one argument: the number of tics to delay for. In the

continued

null loops in the previous examples, a much more efficient construct is

```
20 WAIT 1000
30 GOTO 1000
```

This uses virtually no computer time, since the program spends most of its time in the WAIT.

CANCEL is a means to stop a task from being rescheduled. Remember that all tasks will restart some time after executing an EXIT statement, the time being determined by the RUN statement's second argument. If you CANCEL a task, once it completes its current execution, it will not be reborn. You can restart scheduling for the task by issuing another RUN command with the appropriate arguments. CANCEL has only one argument: the number of the task to cancel. A task can cancel itself, and any task can cancel any other task.

Finally, PRIORITY is a powerful statement that lets you set a relative importance for each task. All tasks, in the absence of a PRIORITY statement, operate at the same priority (i.e., they all compete for time equally). Any task can raise or lower its priority by issuing a PRIORITY statement, followed by a number indicating relative importance. The number can range from 0 to 63, where 63 is the highest priority and 0 is the lowest. Tasks that don't issue a PRIORITY statement operate at priority level 0.

Normally, whenever a tic interrupt is received, BASIC-180 interrupts the current task and, using the task number that is one greater than the task just interrupted, searches for another task that is ready to execute. In other words, it tries to run task 1, then 2, 3, etc. If a task has issued a WAIT instruction and the wait interval has not elapsed, that task will be skipped. This scheduling technique is called round-robin scheduling.

When tasks execute at different priority levels, every time a tic interrupt is received, BASIC-180 searches for the highest-priority task that is ready to execute. If several tasks are ready, but one has a higher priority than any of the others, that task will execute until it executes an EXIT command or a WAIT command, or lowers its priority.

A task can issue a PRIORITY command at any time. Tasks can dynamically raise and lower their priorities as warranted. BASIC-180 allows up to 32 tasks to be active. With each of 32 tasks raising and lowering priorities, issuing CANCEL and RUN commands at each other, you could construct quite a complex program.

Next Month

I'll finish this tutorial on multitasking and the BCC180 with a discussion of BASIC-180's special windowing capability and memory management features. ■

I'd like to acknowledge and personally thank Ken Davidson and Jack Ganssle for their efforts on the BCC180 project. Ken Davidson's extensive knowledge of the HD64180 helped us avoid the omnipresent hardware design pitfalls, and Jack Ganssle's superb software talents helped explain multitasking in a way that can really be understood.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Co., P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984. *Volume VI* covers January 1985 through June 1986.

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800/634-8188 305/392-2046

Inquiry 681.

HANDS OFF™ PC SECURITY
- Locks Hard Disk. - Restricts Floppy Use.
- Protects Subdirectories.
- Normal Use of DOS Commands and Application Software.
- IBM PC, XT, AT and True Compatibles.
- DOS V2.0 and Higher. Hard Disk System.
- Keep Other People's HANDS OFF Your System.
- $89.95 VISA/MC

SYSTEM CONSULTING, INC.
314 Canterbury Dr., Pittsburgh, PA 15238
(412) 963-1624

Inquiry 682.

$59.95!!
Buy the RED Utilities now! Programs include: Disk cache to speed hard disk. Printer spooler. Batch file compiler. Path command for data files. Wild card exceptions. Protect hard disk from accidental formatting. Sort directories. Over 10 more programs. IBM PC. Visa/MC.
The Wenham Software Company
5 Burley St. Wenham, MA 01984 (617) 774-7036

Inquiry 683.

WORD PROCESSING

HEBREW / GREEK / ARABIC
Russian and European Languages. Full featured, multi-language word processor supports on-screen foreign characters with no hardware modifications. $350 (dot matrix) or $500 (laser) + $5 s/h. Or send $15 + $4 s/h for demo. Req. 512K/graphics
Gamma Productions, Inc.
710 Wilshire Blvd., Suite 609, Santa Monica CA 90401
(213) 394-8622

Inquiry 684.

WORD PROCESSING

DuangJan 1.3
Bilingual word processor for English and one of these: Armenian, Bengali, Euro/Latin, Greek, Hindi, Khmer, Lao, Russian, Tamil, Telugu, Thai, Viet, . . . , or create your own language with font editor. $89 + $4 s/h (+ $10 for.) LaserJet + $49. Demo $5. IBM compatibles.
MegaChomp Company
3524 Cottman Avenue, Philadelphia, PA 19149 1606
(215) 331-2746/8138

Inquiry 685.

WORD PROCESSING

PC-Write™ Shareware Ver. 2.71
Fast, full featured word processor/text editor for IBM PC. With spell check, screen clip, mailmerge, split screen, ASCII files, macros. Easy to use. Supports 400 printers - LaserJet + and PostScript. Software, User Guide, and Tutorial on 2 disks for $16. Try it, then register with us for only $89 and get User Manual, 1 year tele-support, newsletter and 2 upgrades. 90-day guarantee. VISA/MC.
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Inquiry 686.

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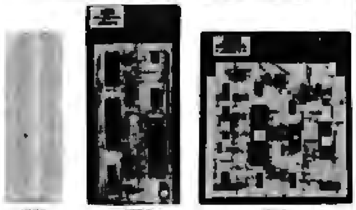
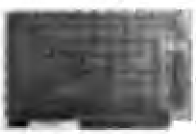


JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ⅜	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5¾	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

Jameco General Purpose Prototype PC Boards



JE417 (Pictured)

- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE415 (6½", No Pads, PC/XT) $14.95
JE417 (6½", Plated w/Pads, PC/XT) $19.95

Extender Board

JE421 (4½" Extender, 31/62 Connector) . . $19.95

DATA BOOKS

30003	National Linear Data Book (82)	$19.95
30005	Logic Data Book - Vol. II (84)	$19.95
30009	Intersil Data Book (87)	$14.95
21398	CMOS Cookbook (88)	$14.95
210830	Intel Memory Handbook (87)	$17.95
230843	Intel Microsystem Hndbk. Set (87)	$24.95

MUFFIN/SPRITE-STYLE FANS

TA450S $11.95
Torin Industries (4.58" sq., 50 cfm)

SU2A1 . . . . $11.95
EG&G Rotron (3.125" square, 34 cfm)

NEW! Switching Power Supply

+5V @ 5A, +12V @1A x 2

• Regulated, 110VAC/220VAC Switchable • 40 watt • Size 8½"L x 3"W x 2⅝"H • Weight: 1½ lbs. • Data Included

PSCC07 . . . . $14.95

Jameco Computer Power Protection

JE1190

JE1190	Power Base	$29.95
JE1191	6-Outlet Power Strip	$11.95
JE1192	300 Watt Back-Up	$299.95
JE1193	500 Watt Back-Up	$399.95

IBM AND APPLE COMPATIBLE DISPLAY MONITORS

SMON

Franklin 12" Green Monochrome
Apple II, II+, *IIe*, *IIc* Compatible
· Composite video output · 18MHz
· Resolution: 800 lines at center
SMON $59.95

12" Amber Monochrome – TTL Input, High Resolution (PC/XT/AT)
AMBER $109.95

14" RGB Color – CGA Compatible Amber/Green/Color Switchable, 640 x 200 Resolution (PC/XT/AT)
TTX1410 . . . . $279.95

14" EGA Color - EGA/CGA Compat., 720 x 350 (max.) resolution (PC/XT/AT)
TE5154 . . . . $399.95

14" Ultrascan Color – CGA/EGA/PGC/VGA Compatible, 800 x 560 (max.) Resolution (PC/XT/AT)
4375M $579.95

IBM PC/XT/AT Compatible Cards

JE1055

JE1050	Mono Graphics Card	$ 59.95
JE1052	Color Graphics Card	$ 49.95
JE1055	EGA Card	$149.95

JAMECO COMPUTER KITS

FREE! PC Write Word Processing Software Included!

Jameco's IBM™ AT Compatible Mini-286 6/8/10/12 MHz Kit!

Part No.	Description	Price
JE1043	1.2M/360K Floppy Control	$ 49.95
JE1015	XT/AT Style Keyboard	$ 59.95
41256-120	512K RAM (18 Chips)	$ 89.10
JE1012	Baby AT Flip-Top Case	$ 69.95
JE1032	200W Power Supply	$ 89.95
JE1022	5¼" High Density Disk Drive	$109.95
JE1003	Baby AT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	$399.95

EGA Monitor TE5154 $399.95
EGA Card JE1055 $149.95
(not included)

Reg. List $868.80
SAVE $68.85!

JE1008 IBM™ AT Compatible Kit $799.95

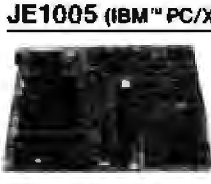
Jameco's 4.77/8MHz Turbo IBM PC/XT Compatible Kit

4164-150	128K RAM (18 Chips)	$ 35.10
41256-150	512K RAM (18 Chips)	$ 77.10
JE1010	Flip-Top Case	$ 34.95
JE1015	XT/AT Style Keyboard	$ 59.95
JE1030	150 Watt Power Supply	$ 69.95
JE1020	5¼" DSDD Disk Drive	$ 89.95
AMBER	12" Amber Monitor	$109.95
JE1001	4.77/8MHz Turbo Motherboard (Zero-K RAM – Includes Award BIOS ROM)	$104.95
JE1071	Multi I/O with Controller and Graphics	$119.95

Regular List $695.85
SAVE $95.90!

JE1005 (IBM™ PC/XT Turbo Compatible Kit) . . $599.95

Jameco's IBM PC/XT/AT Compatible Motherboards



· Award BIOS ROM included

JE1000	4.77MHz (PC/XT)	$ 89.95
JE1001	4.77/8MHz (PC/XT)	$104.95
JE1003	6/8/10/12MHz (AT)	$399.95

Additional Add-Ons Available!

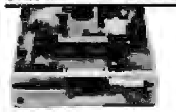
COMPUTER PERIPHERALS

Seagate 20, 30 & 40MB Half Height Hard Disk Drives

ST225K (Pictured)

ST225	20MB Drive only (PC/XT/AT)	$269.95
ST225K	20MB w/Controller (PC/XT)	$319.95
ST238	30MB Drive only (PC/XT/AT)	$299.95
ST238K	30MB w/Cont. (PC/XT/AT)	$339.95
ST251	40MB Drive only (PC/XT/AT)	$469.95
ST251XT	40MB w/Cont. Card (PC/XT)	$549.95
ST251AT	40MB w/Cont. Card (AT)	$589.95

Jameco PC/XT & AT Compatible Disk Drives



JE1022 (Pictured)

JE1020	360K Black Bzl. (PC/XT/AT)	$ 89.95
JE1021	360K Beige Bzl. (PC/XT/AT)	$ 89.95
JE1022	1.2MB Beige Bzl. (AT)	$109.95

DATATRONICS

2400/1200/300 Modems

• Hayes command compatible • Bell 103/212A compatible • Auto dial/auto-answer • FCC approved • 1 year warranty • The 1200H & 2400B include MaxiMite Communication Software • The 1200C & 2400E do not include software

1200H	1200/300 Baud Internal Modem	$ 79.95
2400B	2400/1200/300 Internal Modem	$174.95
1200C	1200/300 Baud External Modem	$119.95
2400E	2400/1200/300 External Modem	$219.95

Prometheus 1200B Internal Modem

PM1200B-2S (Software incl.) ~~$149.95~~ $119.95

Jameco Extended 80-Column Card for Apple *IIe*

• 80 Col./64K RAM • Doubles amount of data your Apple IIe can display as well as its memory capacity • Ideal for word processing • Complete with instructions

JE864 $49.95

ADD12 (Disk Drive II, II+, IIe) **$99.95**

ZUCKERBOARD

TANDY 1000 Expansion Memory Half Card

Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip

TE512	Includes 512K RAM	$119.95
TANC	Plug-in Clock option chip (only)	$39.95

20Meg Hard Disk for Tandy 1000/SX

T20MB	20MB Hard Disk Drive Board for Tandy 1000	$494.95
SX20MB	20MB Hard Disk Drive Board for Tandy 1000SX	$499.95

Accessories for Commodore VIC-20, C-64 & C-128

JE232CM (Pictured)

JE232CM	(RS232 Intec. VIC-20, C-64 and C-128 in 64 mode)	$39.95
CPS10	(C-64 Power Supply)	$39.95
CPS128	(C-128 Power Supply)	$59.95

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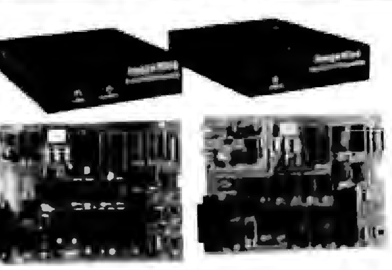
MICROMINT'S Gold Standard in Single Board Computers & Controllers

Announcing

DT01/DR01
Serial Digital Imaging System



MICROMINT INTRODUCES A STAND ALONE SERIAL DIGITAL IMAGING SYSTEM. The MICROMINT **ImageWise™ Serial Digital Imaging System** is the most cost effective and versatile high performance grayscale video digitizing system on the market today. [illegible]

IMAGEWISE SYSTEM SPECIFICATIONS

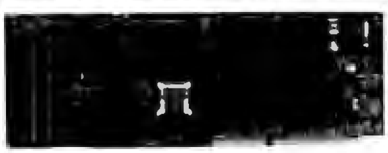
[illegible]

Optional PC Utilities Disk converts ImageWise™ files for use with popular Desktop and Paint Programs.

DT01	ImageWise Digitizer / Transmitter	$349.00
DR01	ImageWise Receiver / Display	$349.00

Announcing

OEM-286 — $775.00
complete PC/AT-CPU



Low Power!

Expansion Card Form Factor!

100% AT Compatible!

MICROMINT's **OEM-286** is a complete PC/AT-CPU and more. The **OEM-286** is the first low power, 100% AT compatible which has been specifically designed for OEM use within the industrial and business sectors. [illegible]

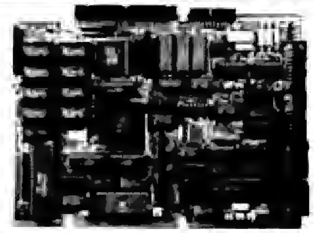
The **OEM-286** is available in both 8 and 10 MHz versions and comes with the Award BIOS.

OEM-286 FEATURES

- 100% AT compatible
- [illegible]

OEM 286/8	8 MHz AT-CPU	$775.00
OEM-286/10	10 MHz AT-CPU	[illegible]
OEM-286/80	8 SLOT PASSIVE BACKPLANE	[illegible]

SB180FX — $409.00
Single Board Computer



SB180FX TECHNICAL SPECIFICATIONS

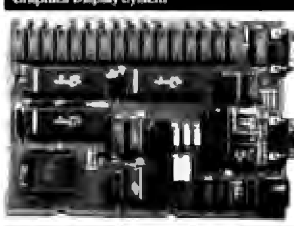
[illegible]

SB180FX-1	SB180FX, 6 MHz computer board populated w/ [illegible] bytes RAM, 64 byte ROM monitor, without SCSI chip. Add $70 [illegible]	$409.00
SB180FX-1-30	[illegible]	[illegible]

SB180 — $299.00
Single Board Computer

SB180-1	SB180 6.144 MHz single board computer w/ [illegible] bytes RAM and ROM monitor. Add [illegible]	[illegible]
SB180-1-20	Same as above with [illegible]	[illegible]
COMM180-S	SCSI Hard Disk Interface	$180.00
SB180-1	OEM 100 QUANTITY PRICE	$195.00

GT180 — $395.00
Graphics Display System



The **GT180** has both TTL RGB and [illegible] an IBM PC keyboard.

The **GT180** offers these features:
- **Advanced** graphics controller provides intelligent link between computer and CRT
- Only [illegible] piggy-back on either an SB180 or SB180FX computer
- High resolution at a low cost [illegible]
- Hardware drawing commands: LINE, RECTANGLE, POLYLINE, POLYGON, CIRCLE, ELLIPSE, ARC, FILLED RECTANGLE, PAINT PATTERN, [illegible]
- Automatic translation of logical X-Y coordinates to physical frame buffer addresses
- Fast drawing speed of 2 million pixels per second
- Provides fully programmable horizontal split screens and window zoom
- Fully supported by **GT180** Graphic Toolbox [illegible]

GT180-1	Graphic Display Expansion Board (TTL RGB only)	[illegible]
GT180-2	Graphic Display Expansion Board (TTL RGB and Analog RGB)	[illegible]

SB180
Software and Accessories

SB180-U	Uniform Disk Format Conversion Software	[illegible]
SB180-Z4SO/TCRM6	Z-NODE Bulletin Board Software	$100.00
SB180-MOD2	Turbo Modula-2	[illegible]
SB180-MOD80	Turbo Modula-2 w/Graphic Toolbox	[illegible]
SB180-CASE	Four half height disk drive enclosure w/power supply, mounting brackets and hardware for the SB180 or SB180FX	$197.00
SB180-CABLE	Set of 4 cables including power, term, disk and print	$ 79.00

BCC22 — $249.00
Term-Mite Smart Terminal

Why pay $500 or more for a smart terminal? The **TERM-MITE ST** gives you all of the following on a single board for less than ½ the price:

- Dimensions, [illegible]
- [illegible] displayable characters
- 80 lines × 80 characters
- Separate transmit & receive baud rates (10 to 19,200bps)
- CRT refresh at 50/60 Hz
- Supports scanned and encoded keyboards
- 11 Graphic Characters
- 25th line reverse video status display
- 21 escape functions
- 16 control functions
- Directly drives composite video or separated sync monitor
- All functions are firmware controlled. Source code available

EDITING FEATURES: [illegible] to screen to space or null, erase to end of page, erase to end of line, absolute cursor addressing

VIDEO ATTRIBUTES: reverse video, half intensity, double height, double width, underlined, blinking and blank characters

BUS CONFIGURATION: MICROMINT BCC compatible or no bus connection necessary for stand-alone operation with parallel keyboard

BCC22	TERM-MITE Smart Terminal Board	$249.00
BCC22K	PARALLEL Encoded ASCII KEYBOARD plugs directly into TERM-MITE	$ 79.00

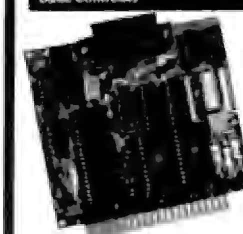
BCC52 — $199.00
BASIC 52 Computer/Controller

The MICROMINT **BCC52 Computer/Controller** is a stand alone single board microcomputer which needs only a power supply and terminal to become a complete system programmable in BASIC or machine language. The **BCC52** uses the Intel 8052AH BASIC microprocessor which contains a ROM resident 8K byte floating point BASIC interpreter. [illegible] a serial terminal port with auto baud rate selection, a serial printer port.

BCC52*	Basic 52 Computer/Controller	$199.00
	OEM 100 QUANTITY PRICE	[illegible]
BCC53	Multi Function Expansion Board with [illegible]	[illegible]

*NOW AVAILABLE IN INDUSTRIAL TEMPERATURE RANGE — CALL FOR INFORMATION

BCC11 — $139.00
Basic Controller



Features:
- Uses Z8 single chip microcomputer
- On board tiny basic interpreter
- [illegible] on board parallel ports & serial port
- [illegible] interrupts
- Just connect a CRT and enter control programs in Basic
- [illegible] of RAM or EPROM memory on board
- Baud rates 110-9600 bps
- Data and address bus available for RAM memory and I/O expansion
- [illegible]

BCC11*	BASIC System Controller	[illegible]

*NOW AVAILABLE IN INDUSTRIAL TEMPERATURE RANGE — CALL FOR INFORMATION

BCC40 — $159.00
Power I/O Expansion Board

The MICROMINT BCC40 POWER I/O Expansion Board provides on/off control and monitoring of eight [illegible] VAC or [illegible] VDC devices. [illegible]

BCC40	POWER I/O Expansion Board (with no power modules)	$159.00
	with 8 Output Modules	[illegible]
	with 8 Input Modules	[illegible]

BCC52 & BCC11
Software and Accessories

BCC52-ROM A	ROM A Utilities BASIC extensions	[illegible]
BCC52-ROM A/B	ROM A and B Utilities BASIC extensions and Assembler	[illegible]
BCC52/41	ROM C Utilities Real Time Clock and Power I/O Software	$ 34.00
BCC52-0K-CLK	SMARTIME BCC52 Clock and ROM C	[illegible]
BCC52-8K-CLK	SMARTIME BCC52 Clock w/8K RAM and ROM	[illegible]
BCC53	Multi Function Exp. Board w/OA [illegible]	$160.00
BCC08	Serial I/O Expansion Board	$149.00
BCC09	RS-232 to 20mA converter	[illegible]
BCC13	8 Bit 16 channel A/D Board	[illegible]
BCC30	12 Bit 16 channel A/D Board	[illegible]
BCC25-4	[illegible] LCD Display	[illegible]
BCC25-8	[illegible] LCD Display	[illegible]
BCC22K	Parallel Encoded ASCII keyboard	$ 79.00

MOTHER BOARDS — CARD CAGES — POWER SUPPLIES

MB02	5 Slot mini-mother board (not compatible with CC01, CC08)	$ 40.00
MB08	8 Slot full mother board (compatible with CC01 and CC08)	$ 84.00
MB-04	44 pin gold card edge connector	$ 8.00
CC01	10 inch Card Cage for use MB08	$ 96.00
CC08	10 inch Card Cage for use MB08	$ 79.00
UPS11	Universal Power Supply — used for single board applications [illegible]	[illegible]
UP605	Card Cage Power Supply designed for 4 or 5 board system [illegible]	$ 79.00
UP810	Heavy Duty Switching Power Supply used for an entire BCC system [illegible]	[illegible]
UP581	[illegible] Programming Power Supply used for EPROM programming on the BCC52 [illegible]	[illegible]

To order call

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PcPRIME 88

640K 8 MHz
10 MHz Optional

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- 100% IBM XT-Compatible
- Phoenix BIOS Installed
- One 12" High Res. Amber Monitor (720x350)
- Hercules Graphics Emulation Card w/Printer Port
- Intel 16-Bit 8088-2 Running at 4.77/8.0 MHz
- 640K RAM on Board
- Two DS/DD 360K Half-Height Fujitsu Direct Drives
- 8 Fully IBM Compatible Expansion Slots
- Runs all MS-DOS Programs Including 1-2-3, Flight Simulator, DBase III Plus, AutoCad, WordStar, Wordperfect, etc.
- Operates MS-DOS, PC-DOS, GW Basic, Novell, Xenix, Unix
- Keyboard Selectable 4.77 and 8.0 MHz
- Accepts all IBM Parts
- 150 watts 110/220 VAC Power Supply w/Four Cables
- Keyboard w/LEDs, Enlarged Return/Shift Keys w/84 Keys
- Two Printer Ports/One Serial Port/One Light Pen Port
- Multi I/O Card: Controls Two Floppy Drives, Printer Port/Game Port/Serial Port, 2nd Optional Battery Back-uped Real Time Clock/Calendar
- 8087 Math Co-Processor Socket Installed on Board
- 8 EPROM Sockets also Installed on Board
- Power-on Self Testing of System Components
- Speaker for Audio or Music Use
- Nickel Plated Enamel Coating, Heavy Duty Metal Case
- Six Slots Still Left Open after Systems Configuration
- Optional 2.5 MB RAM Card for Expanding Memory
- Optional 14" Dual Frequency Swivel-Based Monitor
- Optional 12" Swivel-Based Monitor
- Optional Black/White or Green Monitor
- Optional 10 MHz or NEC V-20 Microprocessor
- Optional Enhanced Keyboard w/101 Keys & 12 F Keys
- Optional 1200/2400 Internal/External Modem
- Optional 1.2 MB 5¼" Drive
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- Optional Color Systems w/High Res. (640x200 or 640x400)
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- Optional Autoswitch EGA Systems/Printer of all Kinds
- Ready for Network/Multi-User/Mouse/Joy Stick Interface
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PcPRIME 88 W/20 MB & 1 Floppy Seagate ST 225, 65 MS $900
PcPRIME 88 w/30 MB & 1 Floppy Seagate ST 238, 65 MS $950

Network/Multi-User Installations

PcPRIME 286

ONE MEGAbyte 10 MHz
12 MHz/"0" Wait Optional

$1,100

- 100% IBM AT-Compatible
- Phoenix BIOS Installed
- One 12" High Res. Amber Monitor (720x350)
- Hercules Graphics Emulation Card w/Printer Port
- Intel 80286 Running at Dual Speed 6 and 10 MHz
- Chip Technology VLSI Chip Set
- Runs all MS-DOS Programs Including 1-2-3, Flight Simulator, DBase III Plus, AutoCad, WordStar, Wordperfect, etc.
- Operates MS-DOS, PC-DOS, GW Basic, Novell, Xenix and Unix
- One Megabyte RAM on Board
- 8 Expansion Slots: Six 16-Bit/Two 8-Bit
- WD-Combined Hard Disk/Floppy Disk Controller Controls Two Hard Disks and Two Floppies
- Keyboard w/LEDs and Enlarged Return/Shift Keys w/84 Keys
- Accepts all IBM Parts
- 220 Watts 110/220 VAC Power Supply w/Four Cables
- Hardware Reset Button/Turbo Light Indicator Installed
- One Fujitsu 1.2 MB Half-Height High Density Floppy
- One RS-232 Serial Card w/2nd Port Optional
- Real-Time Clock & Calendar w/Battery Back-up
- Nickel Plated Enamel Coating, Heavy Duty, Lockable Case Serve also as Keyboard Lock-Out
- Speaker for Audio or Music Use
- Power On Self Testing of System Components
- 80287 Math Co-Processor Socket Installed on Board
- Power and Hard Disk Indicator Lights Installed
- Five Slots Still Left Open after Systems Configuration
- Ready for OS/2 Operating Systems
- Optional 3.5 MB RAM Card for Expanding Memory
- Optional 14" Flat Screen Swivel-Based Monitor
- Optional Black/White or Green Monitor
- Optional Enhanced Keyboard w/101 Keys & 12 F Keys
- Optional 720K/1.44 MB 3½" Half-Height Drive
- Optional 360K DS/DD Half Height Fujitsu Direct Drive
- Optional 1200/2400 Internal/External Modem
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- Optional 12/"0" Wait MHz Systems
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- Optional 14" Dual Frequency Swivel-Based Amber Monitor
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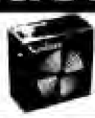

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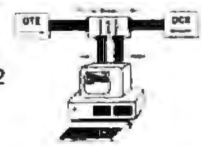

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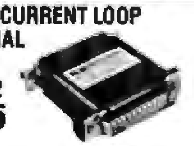

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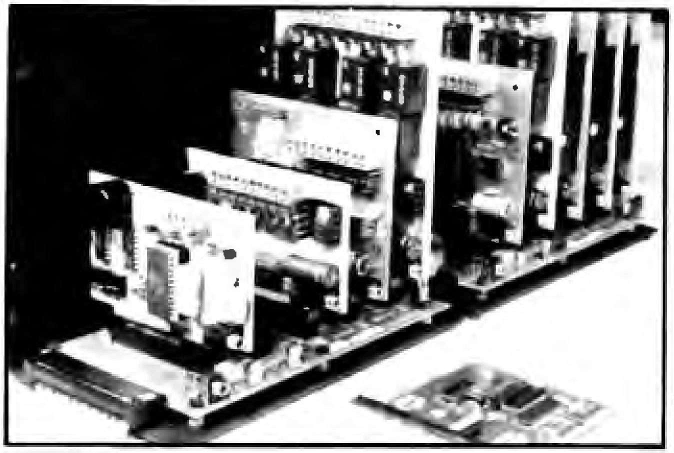

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

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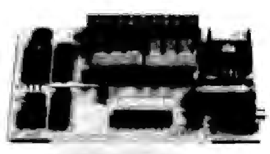
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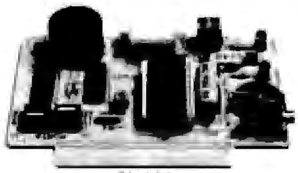
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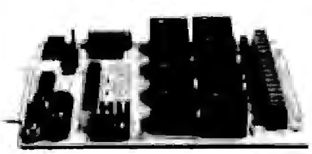
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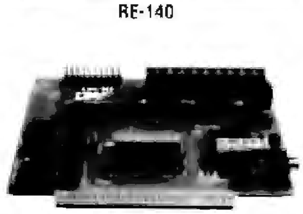
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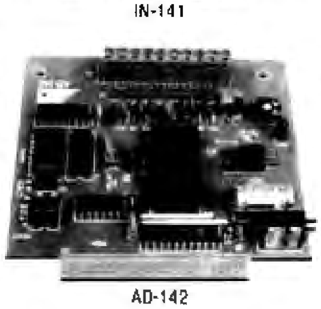
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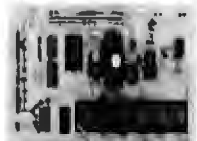

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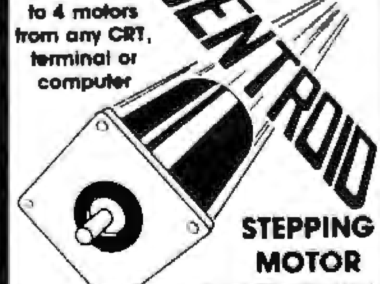

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7402	.18	7475	.35	74158	.65
7404	.18	7476	.35	74173	.65
7405	.18	7485	.35	74174	.65
7406	.35	7486	.35	74175	.65
7407	.35	7490	.35	74176	.65
7408	.25	7493	.35	74181	1.75
7410	.25	7495	.35	74180	2.95
7414	.35	74121	.35	74193	.65
7420	.25	74123	.45	74196	.65
7426	.25	74125	.45	74198	1.65
7427	.25	74126	.45	74221	.75
7430	.25	74148	.65	74273	1.75
7432	.25	74150	1.20	74365	.50
7438	.25	74151	.65	74368	.50
7442	.30	74153	.65	74367	.50
7446	.85	74154	1.20	74368	.50
7447	.95				

74C CHIPS

74C00	$.25	74C154	$2.85	74C374	$1.69
74C02	.25	74C173	.99	74C903	1.19
74C04	.25	74C174	.99	74C906	1.19
74C08	.35	74C175	.99	74C912	6.95
74C10	.35	74C221	1.25	74C922	3.95
74C14	.49	74C240	1.69	74C923	3.95
74C32	.35	74C244	1.69	74C929	4.80
74C90	1.19	74C373	1.69	74C932	14.89

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74LS SERIES

74LS00	$.19	74LS125	$.45	74LS241	$.99
74LS02	.19	74LS126	.49	74LS242	.99
74LS03	.19	74LS138	.45	74LS243	.99
74LS04	.19	74LS139	.45	74LS244	.99
74LS05	.19	74LS153	.59	74LS245	.99
74LS08	.19	74LS154	1.29	74LS257	.69
74LS09	.19	74LS157	.40	74LS258	.69
74LS10	.19	74LS158	.40	74LS259	.69
74LS14	.35	74LS161	.49	74LS273	.99
74LS27	.28	74LS163	.49	74LS322	1.79
74LS30	.25	74LS164	.49	74LS323	1.79
74LS32	.28	74LS165	.49	74LS365	.59
74LS47	.99	74LS166	.99	74LS366	.59
74LS73	.35	74LS173	.49	74LS367	.59
74LS74	.35	74LS174	.49	74LS368	.99
74LS75	.35	74LS175	.49	74LS373	.99
74LS76	.35	74LS189	3.95	74LS374	.99
74LS85	.49	74LS190	.49	74LS393	.99
74LS86	.28	74LS191	.49	74LS624	1.89
74LS90	.45	74LS192	.49	74LS629	1.89
74LS93	.45	74LS193	.49	74LS640	1.89
74LS107	.45	74LS195	.49	74LS641	1.89
74LS109	.45	74LS221	.65	74LS670	.99
74LS123	.49	74LS240	.99	74LS688	1.89

74F SERIES

74F00	$.35	74F153	$.59	74F243	$1.29
74F02	.35	74F157	.59	74F244	1.29
74F04	.35	74F158	.59	74F245	1.29
74F08	.35	74F160	.59	74F251	.79
74F10	.35	74F161	.59	74F258	.79
74F11	.35	74F163	.59	74F280	2.89
74F20	.35	74F174	.69	74F373	1.49
74F32	.35	74F175	.69	74F374	1.49
74F64	.49	74F181	1.99	74F379	1.99
74F74	.49	74F189	2.99	74F399	2.99
74F86	.49	74F219	4.99	74F521	2.89
74F109	.49	74F240	1.29	74F533	2.98
74F138	.49	74F241	1.29	74F534	2.99
74F151	.59				

IC SOCKETS

SOLDERTAIL		HR16S/T	.59	22PINW/W	1.29
8PINL/P	$.10	HR18S/T	.69	24PINW/W	1.29
14PINL/P	.12	HR20S/T	.79	28PINW/W	1.59
16PINL/P	.12	HR22S/T	.89	40PINW/W	1.99
18PINL/P	.16	HR24S/T	.99	HI RES W/W	
20PINL/P	.18	HR28S/T	1.19	HR8W/W	$.79
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HR14S/T	.49				

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CD4002	.18	CD4018	.59	CD4048	.75	CD4070	.29	CD4511	.69	CD4555	.99
CD4007	.59	CD4020	.59	CD4049	.29	CD4071	.29	CD4512	.69	CD4556	.99
CD4008	.59	CD4024	.49	CD4050	.39	CD4072	.29	CD4518	.79	CD4584	.69
CD4009	.59	CD4025	.59	CD4051	.79	CD4073	.79	CD4519	.79	CD14409	6.95
CD4010	.29	CD4027	.35	CD4052	.59	CD4076	.65	CD4520	.79	CD14410	7.95
CD4011	.29	CD4030	.29	CD4053	.59	CD4081	.29	CD4522	.79	CD14411	8.95
CD4012	.29	CD4040	.65	CD4060	1.49	CD4082	.29	CD4538	.79	CD14412	8.95
CD4013	.29	CD4042	.65	CD4063	1.49	CD4093	.35				
CD4016	.59	CD4046	.65	CD4066	.29	CD40103	1.90				

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MOS EPROMS

1702A - 1ms	$5.95	27128 - 450ns	$4.95
2532 - 450ns	4.50	27256 - 200ns	7.95
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2716	4.95	8741	24.95
2716-1	5.95	8742	24.95
27C16	5.95	8748	16.95
TMS2716 450ns		8749	19.95
(3v)	8.49	8751	49.95
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27C32	6.95	68766	19.95
2764 - 450ns	3.95	68701	24.95
2764 - 250ns	4.95	68705P	19.95
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Z80PIO	1.49	Z80ADART	4.99
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Z80ACTC	1.99	Z80BCTC	3.99
Z80APIO	1.99	Z80BPIO	1.99

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82S126	1.29	74S287	1.99
82S129	1.99	74S288	1.99
82S137	2.98	74S471	4.99
82S181	7.98	74S472	6.99
82S191	11.98	PAL 16L8	4.99
74S188	1.29	PAL 20L8	9.95

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8080A	3.95	8224	1.95
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8088	7.95	8251A/S	1.95
8088-2	9.95	8253-5	1.95
80186-6 (5MHz)	14.95	8255-S	2.95
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80286-6 (5MHz)	19.95	8259-5	2.95
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68020/12MHz	149.95	68881/16MHz	219.95

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65C02	11.95	6522	4.95
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6502B	6.95	6545	9.95
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1.8432MHz	3.25	6.000MHz	2.25	16.000MHz	2.25
2.000MHz	2.25	6.144MHz	2.25	18.000MHz	2.25
2.097152MHz	2.25	6.5536MHz	2.25	18.432MHz	2.25
2.4576MHz	2.25	8.000MHz	2.25	20.000MHz	2.25
3.000MHz	2.25	9.000MHz	2.25	22.1184MHz	2.25
3.579545MHz	2.25	10.000MHz	2.25	24.000MHz	2.25
3.6864MHz	2.25	11.000MHz	2.25	32.000MHz	2.25
4.000MHz	2.25	12.000MHz	2.25	40.000MHz	2.25
4.032MHz	2.25	13.000MHz	2.25	12.288MHz	1.50
5.000MHz	2.25				

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1.8432MHz	5.50	8.000MHz	5.50	16.257MHz	5.50
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2.4576MHz	5.50	9.830MHz	5.50	18.432MHz	5.50
3.000MHz	5.50	10.000MHz	5.50	19.6608MHz	5.50
3.6864MHz	5.50	11.000MHz	5.50	20.000MHz	5.50
4.000MHz	5.50	12.000MHz	5.50	22.000MHz	5.50
4.9152MHz	5.50	12.200MHz	5.50	24.000MHz	5.50
5.000MHz	5.50	14.318MHz	5.50	24.576MHz	5.50
5.0688MHz	5.50	15.000MHz	5.50	27.250MHz	5.50
6.000MHz	5.50	15.360MHz	5.50	42.200MHz	5.50
6.144MHz	5.50	15.758MHz	5.50		

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HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
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4164-120	65536x1	(120ns)	1.99
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TMS4164	65536x1	(150ns)	1.95
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41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	3.49
41256-120	262144x1	(120ns)	3.95
41256-100	262144x1	(100ns)	4.95
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1 MB-120	1048576x1	(120ns)	31.95
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2716	2048x8	(450ns)(25V)	3.49
2716-1	2048x8	(350ns)(25V)	3.95
TMS2532	4096x8	(450ns)(25V)	5.95
2732	4096x8	(450ns)(25V)	3.95
2732A	4096x8	(250ns)(21V)	3.95
2732A-2	4096x8	(200ns)(21V)	4.25
27C64	8192x8	(250ns)(12.5V CMOS)	4.95
2764	8192x8	(450ns)(12.5V)	3.49
2764-250	8192x8	(250ns)(12.5V)	3.69
2764-200	8192x8	(200ns)(12.5V)	4.25
MCM68766	8192x8	(350ns)(21V)(24 PIN)	15.95
27128	16384x8	(250ns)(12.5V)	4.25
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27256	32768x8	(250ns)(12.5V)	5.95
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27C512	65536x8	(250ns)(12.5V CMOS)	12.95

xxV=Program Voltage

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8203	14.95	8255-5	1.59
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8212	1.49	8259-5	2.29
8216	1.49	8257	2.25
8224	2.25	8272	4.39
8228	2.25	8274	4.95
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8243	1.95	8279-5	2.95
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74LS00

74LS00	18	74LS112	29	74LS241	69
74LS01	18	74LS122	45	74LS242	69
74LS02	17	74LS123	49	74LS243	69
74LS03	18	74LS124	2.75	74LS244	69
74LS04	16	74LS125	39	74LS245	79
74LS05	18	74LS126	39	74LS251	49
74LS08	18	74LS132	39	74LS253	49
74LS09	18	74LS133	45	74LS257	39
74LS10	16	74LS136	39	74LS258	49
74LS11	22	74LS138	39	74LS259	1.29
74LS12	22	74LS139	39	74LS260	49
74LS13	26	74LS145	99	74LS266	.39
74LS14	39	74LS147	99	74LS273	79
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74LS20	17	74LS151	39	74LS280	1.98
74LS21	22	74LS153	39	74LS283	59
74LS22	22	74LS154	1.49	74LS290	89
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74LS30	17	74LS157	35	74LS322	3.95
74LS32	18	74LS158	29	74LS323	2.49
74LS33	28	74LS160	29	74LS365	39
74LS37	26	74LS161	39	74LS367	.39
74LS38	26	74LS162	49	74LS368	39
74LS42	39	74LS163	39	74LS373	79
74LS47	75	74LS164	49	74LS374	79
74LS48	85	74LS165	65	74LS375	95
74LS51	17	74LS166	95	74LS377	79
74LS73	29	74LS169	95	74LS390	1.19
74LS74	24	74LS173	49	74LS393	79
74LS75	29	74LS174	39	74LS541	1.49
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74LS85	49	74LS192	69	74LS645	99
74LS86	22	74LS193	69	74LS670	89
74LS90	35	74LS194	69	74LS682	3.20
74LS92	49	74LS195	69	74LS688	2.40
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74LS95	.49	74LS197	59	25LS2521	2.80
74LS107	34	74LS221	59	26LS31	1.95
74LS109	36	74LS240	69	26LS32	1.95

7400

7400	19
7402	19
7404	19
7406	.29
7407	.29
7408	24
7410	19
7411	25
7414	49
7416	25
7417	25
7420	19
7430	19
7432	29
7438	29
7442	49
7446	69
7447	89
7473	.34
7474	.33
7475	.45
7476	.35
7483	50
7485	59
7486	.35
7489	2.15
7490	.39
7493	35
74121	.29
74123	.49
74125	.45
74150	1.35
74151	.55
74153	55
74154	1.49
74157	55
74159	1.65
74161	69
74164	85
74166	1.00
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LM317T	69	LM1488	49
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LM319	1.25	LM1496	85
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LM335	1.79	CA3146	1.29
LM336	1.75	MC3373	1.29
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LM339	59	MC3480	8.95
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LF356	99	LM3911	2.25
LF357	99	LM3909	98
LM358	59	LM3914	1.89
LM380	89	MC4024	3.49
LM383	1.95	MC4044	3.99
LM386	89	RC4136	1.25
LM393	45	RC4558	69
LM394H	5.95	LM13600	1.49
TL494	4.20	75107	1.49
TL497	3.25	75110	1.95
NE555	29	75150	1.95
NE556	49	75154	1.95
NE558	79	75188	1.25
NE564	1.95	75189	1.25
LM565	95	75451	.39
LM566	1.49	75452	.39
NE590	2.50	75477	1.29

H-TO-5 CAN. K-TO-3. T-TO-220

CMOS/HIGH SPEED CMOS

4001	19	4066	.29	74HC154	1.0
4011	19	4069	.19	74HC157	.5
4012	25	4070	.29	74HC244	[illegible]
4013	35	4081	.22	74HC245	[illegible]
4015	29	4093	.49	74HC273	[illegible]
4016	29	14411	9.95	74HC373	[illegible]
4017	49	14433	14.95	74HC374	[illegible]
4018	69	14497	6.95	74HCT00	[illegible]
4020	59	4503	.49	74HCT02	[illegible]
4021	69	4511	.69	74HCT04	[illegible]
4023	25	4518	.85	74HCT08	[illegible]
4024	49	4528	.79	74HCT32	[illegible]
4025	25	4538	.95	74HCT74	[illegible]
4027	39	4702	9.95	74HCT138	[illegible]
4028	65	74HC00	.21	74HCT139	[illegible]
4040	69	74HC02	.21	74HCT161	[illegible]
4042	59	74HC04	.25	74HCT240	[illegible]
4044	69	74HC08	.25	74HCT244	[illegible]
4046	.69	74HC10	.25	74HCT245	[illegible]
4047	69	74HC14	.35	74HCT273	[illegible]
4049	.29	74HC32	.35	74HCT373	[illegible]
4050	.29	74HC74	.35	74HCT374	[illegible]
4051	.69	74HC86	.45	74HCT393	[illegible]
4052	.69	74HC138	.45	74HCT4017	1.
4053	.69	74HC139	.45	74HCT4040	[illegible]
4060	.69	74HC161	.59	74HCT4060	1.

6500

1.0 MHz

6502	2.25
65C02 (CMOS)	7.95
6520	1.65
6522	2.95
6526	13.95
6532	5.95
6545	2.95
6551	2.95

2.0 MHz

6502A	2.69
6520A	2.95
6522A	5.95
6532A	11.95
6545A	3.95
6551A	6.95

3.0 MHz

6502B	4.25

6800

1.0 MHz

6800	1.95
6802	2.85
6803	3.95
6809	2.95
6809E	2.95
6810	1.95
6820	2.95
6821	1.25
6840	3.95
6843	4.95
6844	6.95
6845	2.75
6847	4.75
6850	1.95
6883	22.95

2.0 MHz

68B00	2.95
68B02	3.95
68B09E	5.49
68B09	5.95
68B21	1.85
68B45	4.95
68B50	1.75
68000	9.95

Z-80

2.5 MHz

Z80-CPU	1.25

4.0 MHz

Z80A CPU	1.29
Z80A CTC	1.69
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A PIO	1.89
Z80A-SIO 0	5.95
Z80A-SIO 1	5.95
Z80A-SIO 2	5.95

6.0 MHz

Z80B-CPU	2.75
Z80B CTC	4.25
Z80B PIO	4.25
Z80B-DART	6.95
Z80B SIO 0	12.95
Z80B-SIO 2	12.95
Z8671 ZILOG	9.95

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MM58174	9.95
MSM5832	2.95

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BR1941	4.95
4702	9.95
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1797	12.95
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2793	19.95
2797	29.95
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UPD765	4.39
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MB8877	12.95
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2143	6.95
9216	6.29

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AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	3.95
IM6403	9.95
INS8250	6.95
NS16450	10.95

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ADC0809	3.85
DAC0800	3.29
DAC0808	1.99
DAC1022	5.95
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8T97	59
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16R6	$2.95
16R4	$2.95

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2.4576	1.95
3.579545	1.95
4.0	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
16.0	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

OSCILLATORS

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1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	5.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

74F/74S

74F00	.35
74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	.89
74F240	1.29
74S00	.29
74S02	.29
74S04	.29
74S08	.35
74S10	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S124	2.75
74S138	.79
74S153	.79
74S157	.79
74S158	.95
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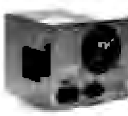

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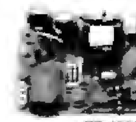

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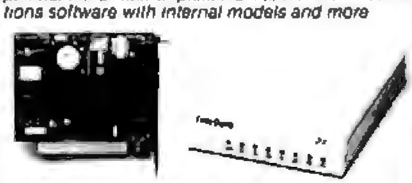

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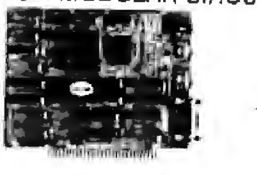

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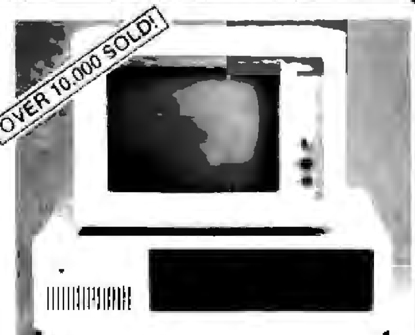

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Index of companies covered in articles, columns, or news stories in this issue.
Each reference is to the first page of the article or section in which the company name appears.

EDITORIAL INDEX BY COMPANY

COMING UP IN BYTE

Products in Perspective:

The section begins with What's New and continues with Short Takes on Flight Control, Awareness, Friendly Finder, PC Weather Pro, Manuscript 2.0, The Icon Shell, and Focal Point.

Our Group Review covers EGA/VGA boards and includes a sidebar of comment and user experience from BIX.

System reviews include the Zenith Z-386, a comparison of the Power Mate 2 and Vectra ES, and the Tandy 1400 LT.

Hardware reviews include third-party add-on color monitors for the Macintosh II and a variety of add-on accelerator boards for the Macintosh SE.

Software reviews include the Trilogy language as well as a new version of DOS from Wendin.

Application reviews cover Microsoft Excel, Microsoft Works, and Borland's Reflex Plus.

Jerry Pournelle and Ezra Shapiro talk about the joys and frustrations of microcomputer use and the products that constitute the biggest joys and frustrations this month.

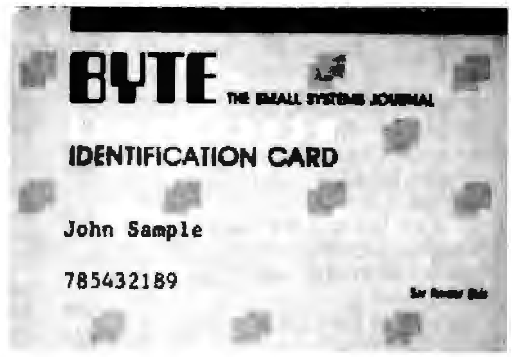
In Depth:

The In Depth section focuses on floating-point processing. Included will be articles on: memory-mapped coprocessors; programming the Intel 80387; a primer on floating-point processing; what it takes to write a good IEEE-754 emulator; a description of the functions and capabilities of the Weitek coprocessor board; and a resource guide to further products and information.

Features:

Steve Ciarcia presents Part 3 of his series on building the BCC180 multitasking controller. Dick Pountain's Focus on Algorithms discusses algorithms for producing "Multicolumn Paged Text."

Important TIPS* for BYTE Subscribers: Receive Product Information 10 Days Earlier!



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Alphabetical Index to Advertisers

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SEND FOR YOUR SUBSCRIBER I.D. CARD

1) If you are a new subscriber or have lost your I.D. card, circle #1 on the Reader Service Card; **attach mailer label**. We will immediately send your personal TIPS subscriber card.

GET PREPARED

2) Write your Subscriber Number, as printed on your Subscriber I.D. Card, in boxes in Step 5 below. (Do not add 0's to fill in blank boxes)

3) Write numbers for information desired in boxes in Step 7b below. (Do not add 0's to fill in blank boxes.)

CALL TIPS

4) Now, on a Touch-Tone telephone dial: (413) 442-2668 and wait for voice commands.

ENTER YOUR SUBSCRIBER AND ISSUE NUMBERS

5) When TIPS says: "Enter Subscriber Number"
(Enter by pushing the numbers and symbols [# or * enclosed in the boxes] on telephone pad ignoring blank boxes)
Enter ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ [#] [#]

6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [2] [8] [#] [#]

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

1. ☐ ☐ ☐ [#] [#]
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END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

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2 Check all the appropriate answers to questions "A" through "F".

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2 ☐ MIS/DP, Programming
3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
1 ☐ 25 or fewer
2 ☐ 26–99
3 ☐ 100–499
4 ☐ 500–999
5 ☐ 1000 or more

C. Reason for request: (Check all that apply).
1 ☐ Business use for yourself
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D. Your next step after information is received:
1 ☐ Purchase order
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3 ☐ Specification/Recommendation

E. Please indicate the product categories for which you influence the selection or purchase at your (or your client's) company or organization. (Check all that apply).
1 ☐ Microcomputers
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4 ☐ Accessories and supplies

F. For how many microcomputers do you influence the purchase of products at your (or your client's) company or organization?
1 ☐ 1
2 ☐ 2–4
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A. What is your primary job function? (Check one only)
1 ☐ Business Owner, General Management, Administrative
2 ☐ MIS/DP, Programming
3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
1 ☐ 25 or fewer
2 ☐ 26–99
3 ☐ 100–499
4 ☐ 500–999
5 ☐ 1000 or more

C. Reason for request: (Check all that apply).
1 ☐ Business use for yourself
2 ☐ Business use for your company
3 ☐ Personal use

D. Your next step after information is received:
1 ☐ Purchase order
2 ☐ Evaluation
3 ☐ Specification/Recommendation

E. Please indicate the product categories for which you influence the selection or purchase at your (or your client's) company or organization. (Check all that apply).
1 ☐ Microcomputers
2 ☐ Peripherals
3 ☐ Software
4 ☐ Accessories and supplies

F. For how many microcomputers do you influence the purchase of products at your (or your client's) company or organization?
1 ☐ 1
2 ☐ 2–4
3 ☐ 5–9
4 ☐ 10 or more

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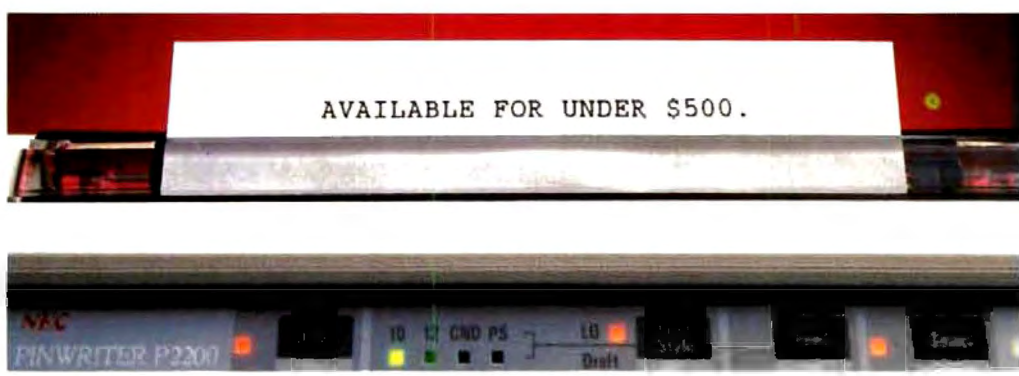

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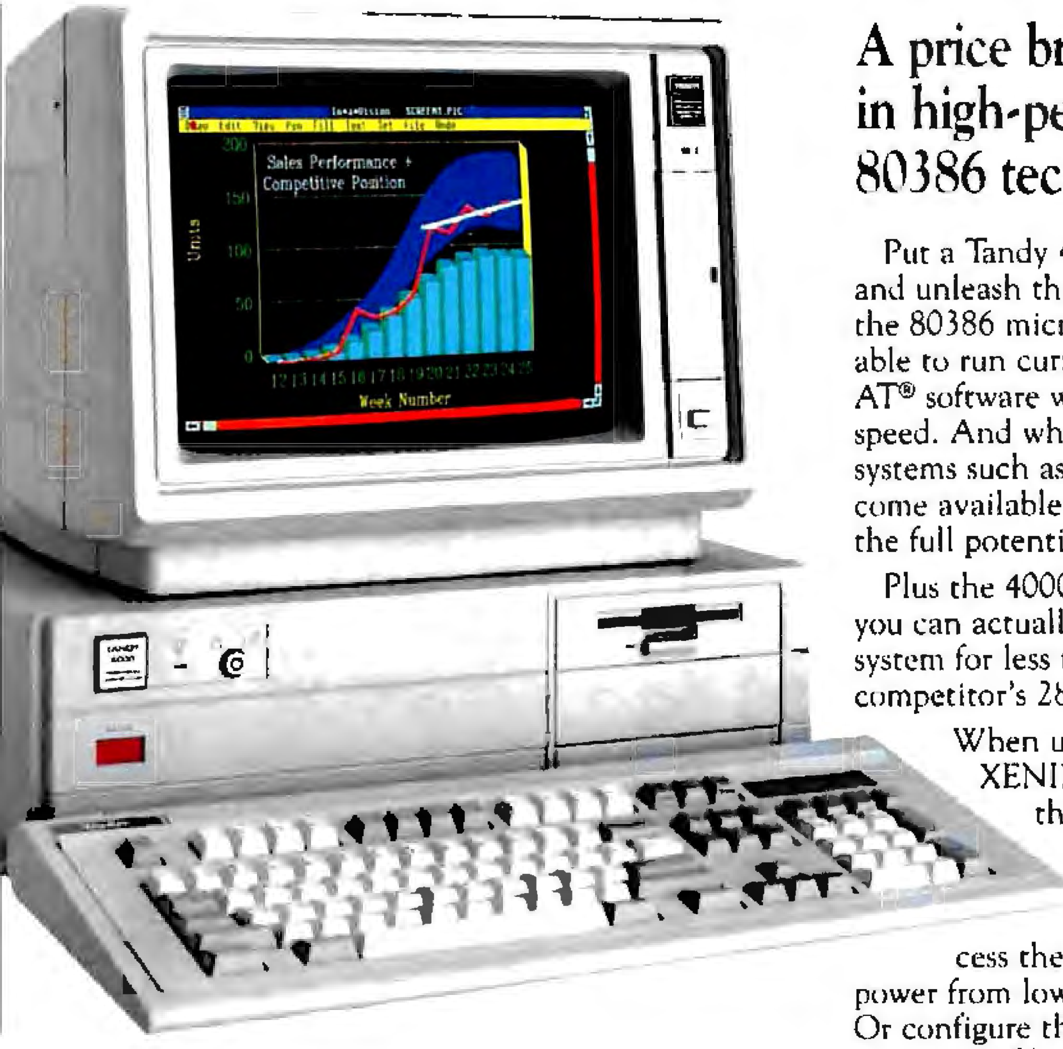

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