BYTE

THE SMALL SYSTEMS JOURNAL®

JUNE 1987 VOL.12, NO.6

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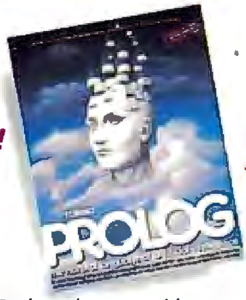

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VOLUME 12
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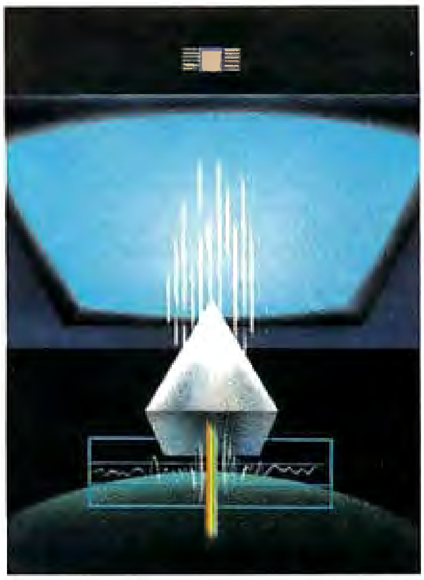

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BYTE (ISSN 0360-5280) is published monthly with additional issues in June and October by McGraw-Hill Inc. Founder: James H. McGraw (1860-1948). Executive, editorial, circulation, and advertisingoffices: One Phoenix Mill Lane, Peterborough, NH 03458, phone (603) 924-9281. Office hours: Monday through Thursday 8:30 AM—4:30 PM, Friday 8:30 AM—1:00 PM, Eastern Time. Address subscriptions to BYTE Subscriptions, P.O. Box 590, Martinsville, NJ 08836. Postmaster: send address changes, USPS Form 3579, undeliverable copies, and fulfillment questions to BYTE Subscriptions, P.O. Box 596, Martinsville, NJ 08836. Second-class postage paid at Peterborough, NH 03458 and additional mailing offices. Postage paid at Winnipeg, Manitoba. Registration number 9321. Subscriptions are $22 for one year $40 for two years, and $58 for three years in the U.S. and its possessions. In Canada and Mexico, $25 for one year, $45 for two years, $65 for three years. $69 for one year air delivery to Europe. 31,000 yen for one year air delivery to Japan, 15,600 yen for one year surface delivery to Japan, $37 surface delivery elsewhere. Air delivery to selected areas at additional rates upon request. Single copy price is $3.50 in the U.S. and its possessions, $4.25 in Canada and Mexico, $4.50 in Europe, and $5 elsewhere. Foreign subscriptions and sales should be remitted in U.S. funds drawn on a U.S. bank. Please allow six to eight weeks for delivery of first issue. Printed in the United States of America.

Address editorial correspondence to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Unacceptable manuscripts will be returned if accompanied by sufficient postage. Note responsible for lost manuscripts or photos. Opinions expressed by the authors are not necessarily those of BYTE.

Subscription questions or problems should be addressed to: BYTE Subscriber Service, P.O. Box 328, Hancock, NH 03449

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EDITORIAL

Liberation and Fragmentation

IBM's long-awaited new Personal System/2 computers have at last arrived, and with them the promise of OS/2, the operating system jointly developed by Microsoft and IBM. Our rush article about the new IBM systems appears in this issue on page 100. Rick Grehan and Eva White offer a more detailed overview of OS/2 in this issue on page 116. Rather than repeating the particulars of the IBM announcements here, I will describe some salient points and look at the effects of IBM's and other recent announcements on the industry and the user community.

Contrary to many predictions, IBM did introduce an 80386 machine, the Model 80, and it will be available in July 1987 rather than in 1988. Furthermore, the Model 80 has a new high-performance 32-bit bus called Micro Channel. Its slots can handle both memory and I/O, and its design includes support for multiple processors. The Model 80 gives IBM an outstanding foundation for its personal computers for the next 5 to 10 years. Models 50 and 60, which are 10-megahertz 80286 machines with a 16-bit Micro Channel that is a subset of the 32-bit bus, join the Model 80 in having the new VGA 640 by 480 graphics as standard equipment. Models 50, 60, and 80 all have convenient high-capacity 1.44-megabyte microfloppies as standard equipment. These three models together define the new hardware standard.

The wonderful news about systems software is the announcement of OS/2, which finally will liberate users and developers from the 640K-byte memory-addressing limitation that has deprived IBM-compatible computing of goodies like the graphical user interfaces on the Macintosh, the Atari ST, and the Amiga. OS/2 will give software developers 16 megabytes of 64K-byte segments—not the ideal linear address space, but a big improvement. The IBM world should now have the means to support a graphical user interface.

But there is also some bad news regarding new systems software. Microsoft had been preparing us to accept the late arrival of OS/2, but it comes as a shock that the new Presentation Manager will not be available with the standard release of OS/2 in early 1988. While developers will get OS/2 kits in August, the kit won't include support for the Presentation Manager until late this year.

Together with Apple's announcement of the Macintosh II and SE, the IBM announcement reshapes the marketplace. Both Apple and IBM now offer users and software developers outstanding foundation machines for the years ahead. The Macintosh II uses the 68020, and the Personal System/2 Model 80 uses the 80386, which can address memory as a large linear space. That feature of the 80386 offers real liberation from the memory management constraints of previous Intel processors. Apple's Macintosh II uses the standard 32-bit NuBus, while IBM's Model 80 uses the 32-bit Micro Channel.

Four Major Fragments, with More Possible

Where does all this leave us? For software developers and users alike, the personal computer market has now split into four major fragments: MS-DOS, OS/2, Macintosh, and Unix. And further fragmentation is possible. MS-DOS dominates now, but it will be supplanted in the long term. OS/2 is the obvious new target for major development projects—but work can't start on anything that uses the Presentation Manager until late1987. Since the Presentation Manager is to be the standard user interface for OS/2, applications software for OS/2 will be very late.

Today—and for at least the next year—both Macintosh and Unix will have much larger installed bases than OS/2. The installed base of Macintoshes has been growing rapidly since the introduction of the Macintosh Plus, with the SE and the Macintosh II sure to increase the pace of growth. And the Macintosh systems software, including the graphical user interface, is not only well defined but also friendly and familiar. There is a rich collection of applications software that exploits the Macintosh user interface. For those who must run PC applications, there is an XT card for the Macintosh SE and an AT card for the Macintosh II. Indeed, a Macintosh II with the AST 80286 card costs less than a Personal System/2 Model 80 with floating-point processor and comparable mass storage and display. Apple continues to work on a multitasking version of the Macintosh operating system. Apple's challenge is to introduce multitasking before the arrival of OS/2, which also provides multitasking.

The installed base of Unix has also grown, although more gradually than that of the Macintosh, and may now be sufficient to drive the development of an attractive assortment of applications software. Consider this also: Unix will run on the IBM Personal System/2 Model 80, the Macintosh II, the IBM PC RT, Sun and Apollo workstations, and many supermicrocomputers and minicomputers. Since Unix supports multitasking, and through the new X-Windows standard will support a windowing environment, Unix offers now some of the future attractions of OS/2. And the infamous overhead of Unix is not much greater than the overhead associated with OS/2. Unix with a DOS emulator to run old PC software could win new friends. Some software developers will find that Unix is now the easiest single path to the greatest variety of high-end hardware.

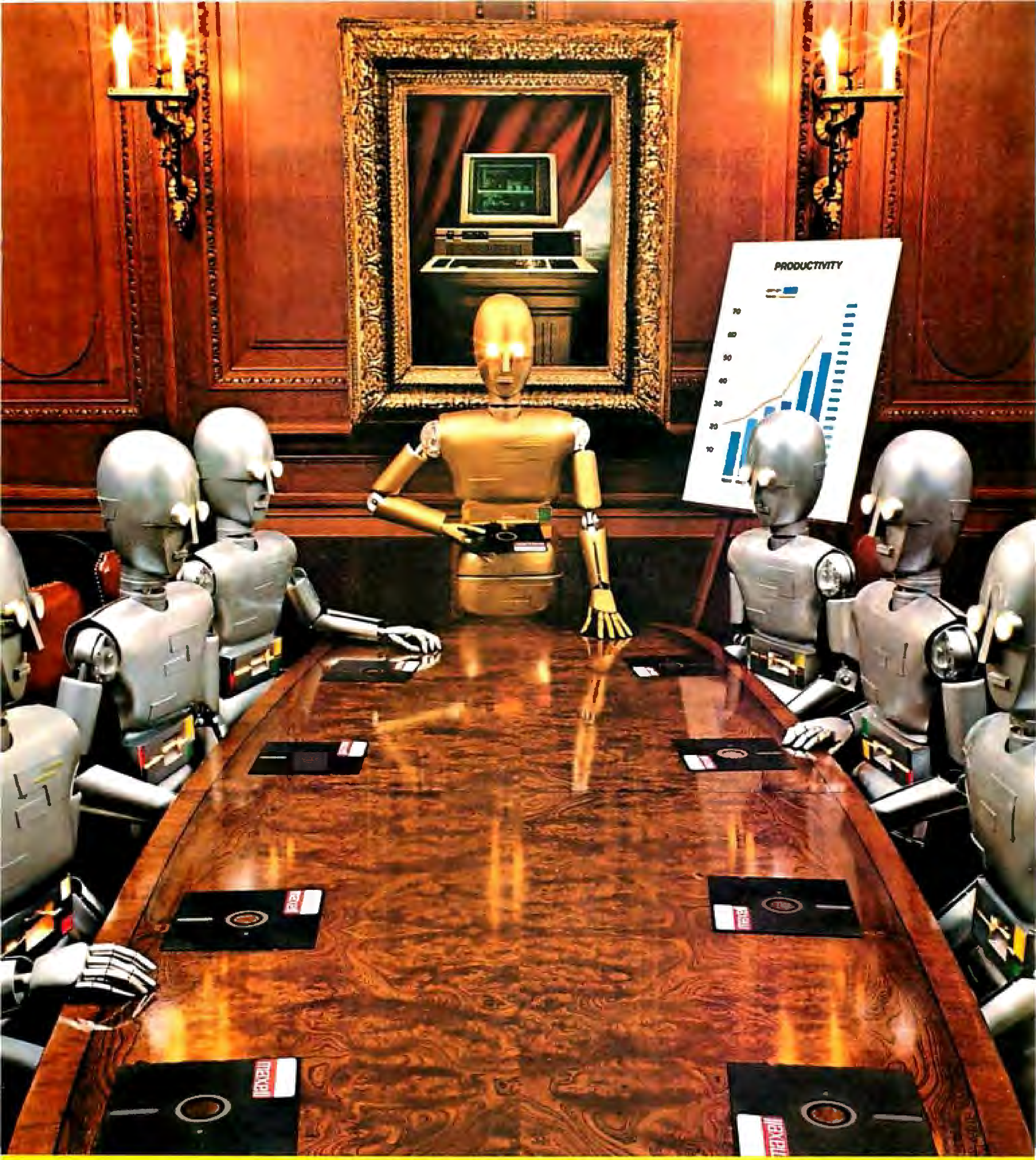
There is the possibility of still further fragmentation of the market. IBM will offer sometime in 1988 an extended version of OS/2. This version will include a relational database compatible with IBM mainframe databases and a wealth of communications support for links with large IBM systems. OS/2 Extended Version seems to be IBM's strategy for providing integration from the largest systems to the smallest in large corporations. OS/2 Extended Version may represent for some developers the most attractive part of the market. Also, we can't entirely rule out the entrance of a new 80386 operating system on the scene.

Critical Choices

The age of the commodity computer is passing. If you want to do a major computing task on a small computer, you face a rich range of choices. Things are getting much better—but no easier.

The best news of all is that both IBM and Apple have now shown outstanding new architectures that can carry us far into the future. Starting in July, we will devote regular coverage to next-generation computing that focuses on 80386 and 68020 systems. We will compare and contrast the new systems as quickly as we can get our hands on them.

—Phil Lemmons
Editor in Chief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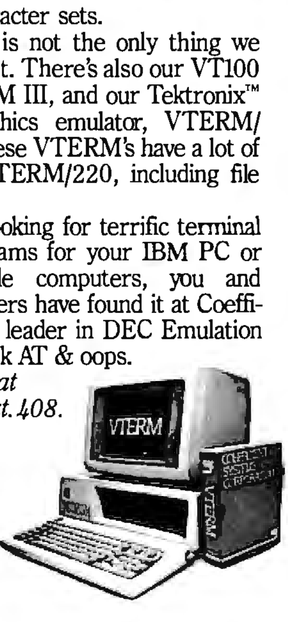

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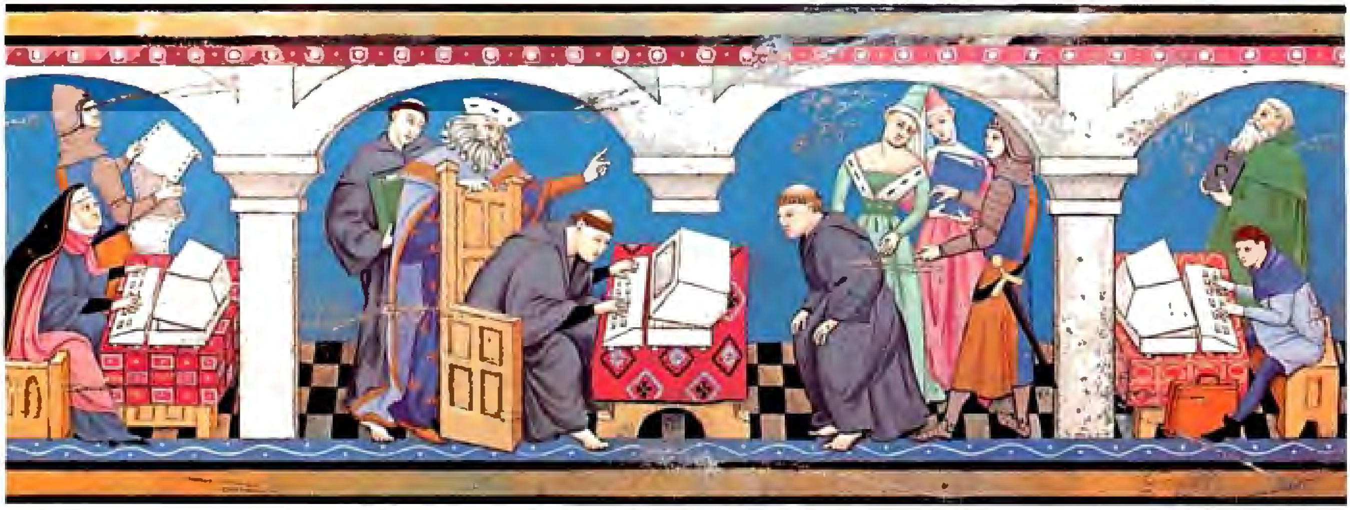

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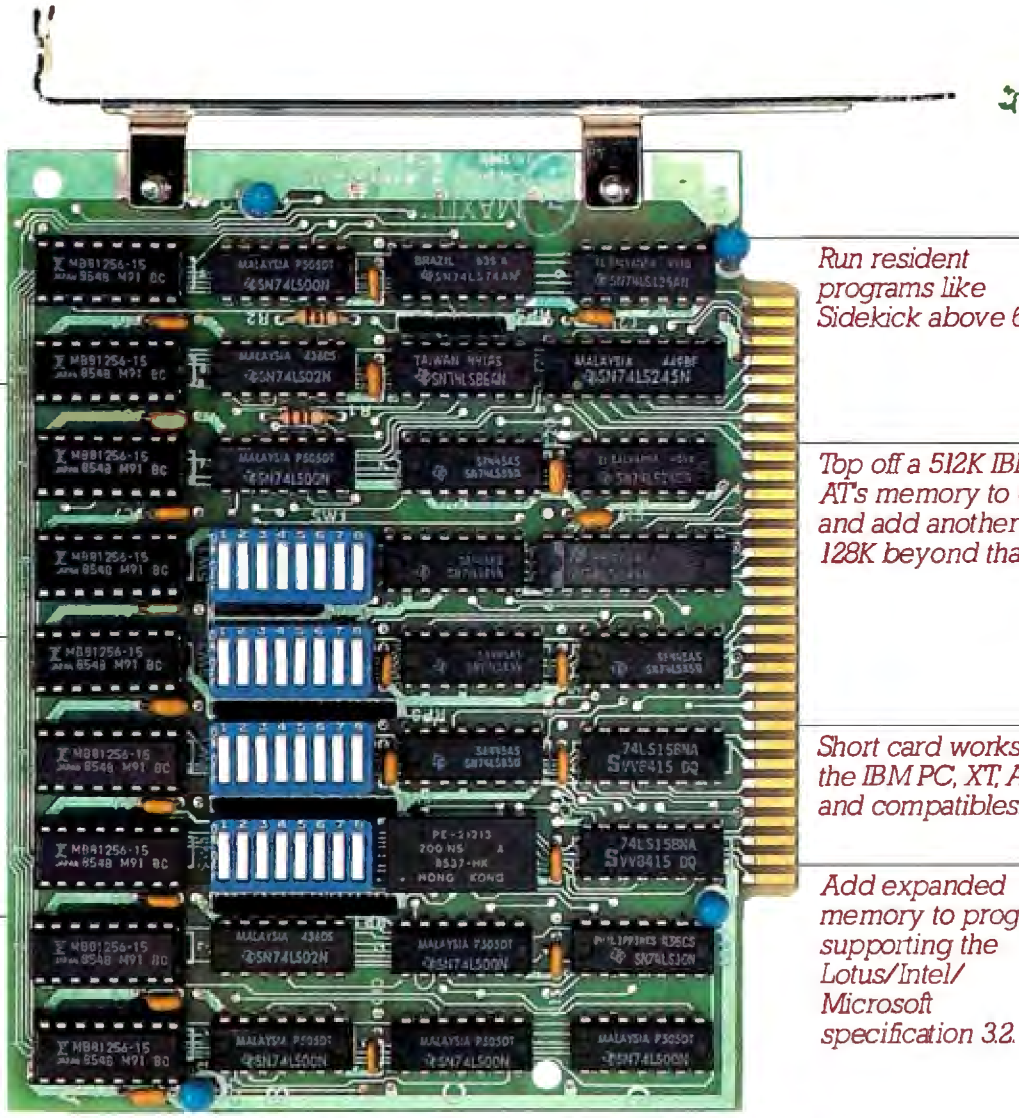

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LETTERS

including Review Feedback

PC Scheme

The review entitled "PC Scheme: A Lexical LISP" by William G. Wong (March) emphasized some of PC Scheme's advanced features, such as continuations and engines, but it did not mention environments (used to implement SCOOPS), streams (like lists, but with delayed evaluation), and ports (files and windows), which are also first-class objects. Also, Mr. Wong faulted PC Scheme for not including record structures, when, in fact, its `define-structure` is similar to `defstruct` in Common LISP and creates extensible structures whose instances are equipped with accessors and recognizers.

PC Scheme has a `string-read` function, called `read-line`, which reads a line from a port and returns it in a string. However, `read-line` does not echo when reading from input or from a window, a fact that impedes interactive programming.

Readers should note that PC Scheme also runs on the TI Professional, and it gives you control of the excellent graphics on this computer, as well as on the IBM PC. It also gives full control of character attributes on either computer.

Finally, Abelson and Sussman's remarkable book is not the only source on PC Scheme. Daniel P. Friedman's *The Little LISPer* uses PC Scheme syntax, and Kent Dybvig's new *The Scheme Programming Language* gives extended examples, including examples using continuations and engines.

Roger B. Kirchner
Northfield, MN

Atari 1040ST

I just read the review of the Atari 1040ST by Dave Menconi (February). Overall, it was a positive and generally unbiased review. However, there are a couple of points that I would like to bring up.

In the Disk Access in BASIC Read and Write tests, I found it disturbing to see ST BASIC results being graphed against the more optimized BASICs of the Amiga and the Macintosh. ST BASIC is the slowest, most clumsy BASIC available for the ST. It takes minutes instead of seconds to load relatively large files. For the reader to see this in a comparison with the other computers, it gives the illusion of the 1040ST being generally slow. This is not the case. Quite a few complete BASICs for the ST are lightning fast, such as Fast BASIC from Computer Concepts or LDW BASIC. These alternate BASICs would speed up the 1040ST's test results significantly.

My second point concerns disk I/O speed and storage size. The ST drive capacity is 360K bytes and 720K bytes, as Mr. Menconi states. However, if you use one of the many formatting programs available in the public domain, you can pack just over 400K bytes on single-sided drives and around 809K bytes on double-sided drives while maintaining compatibility with all file-copy and file-load applications.

Rod Swanson
Napa, CA

I could not agree with you more that using ST BASIC in the benchmarks skewed the results. Unfortunately, at the time that I wrote the review (I completed it in September 1986 and started it some months before that), there were few alternative BASICs available. Thank you for pointing out some of the alternatives that have become widely available since then.

—Dave Menconi

I enjoyed Dave Menconi's review of the Atari 1040ST. Based on my experience with my functionally equivalent Atari, I have a few comments relative to the basically excellent review. First, I've found a good way to use the right mouse button with the desktop. When you have two or more windows open, you can hold down the right mouse button and use the left button to make a selection from another window. I have found this particularly useful when copying files from one disk (or RAM disk) to another disk, since you do not have to change the active window when using the right mouse button.

Next, Mr. Menconi states that if you have a folder open, "you cannot access any of the other files" on that drive. Actually, you can access those files: You simply open a second window for that drive by clicking on that drive. You can have up to four desktop windows open at any one time for accessing files.

Finally, Mr. Menconi says that "the icons are arranged for you." True, the icons do have a default position, but you are free to move them wherever you want on the screen. Then you can point to and click on the option to save the desktop. Thus, the next time you boot from that disk, the icons will come up in the same position you established.

E. Frank Carlson
Maple Valley, WA

Thank you for comments, especially your tip about the left and right mouse buttons. I'd like to note that the icons I described as being arranged for you are not the icons on the desktop, but the file icons in a disk window, which are, indeed, arranged for you.

—Dave Menconi

This letter is a group effort in response to the review of the Atari 1040ST. We all have extensive experience with our Atari STs, and many of us have a great deal of experience on many other kinds of computers, including the Macintosh and the IBM PC. The review, in our opinion, was written with a preconceived bias and, as a whole, was negatively presented.

One comparison that Mr. Menconi made was between the 1040ST's TOS operating system and the Macintosh's Finder. He mentioned that the Finder was intended to be the "perfect user interface." If you are going to compare the 1040ST to a possible advantage of the Mac, then at least mention that the Mac is incapable of displaying color, a severe disadvantage if you consider user-friendliness. It should also be noted that the ST can run without the GEM desktop with any of several command-line interpreters using MS-DOS, Unix, or CP/M commands.

For some reason, Mr. Menconi presented the fact that the 1040ST does not include an RF modulator as a real negative. Of course, the IBM PC and the Macintosh don't have one, either. But if

continued

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Because BYTE receives hundreds of letters each month, not all of them can be published. Letters can not be returned to authors. Generally, it takes four months from the time BYTE receives a letter until it is published.

you really need one, you can buy a third-party RF converter and add it to your ST. However, we are lost as to why someone would want to buy a $1000 computer with the graphics quality of the ST and use a standard TV as the display screen.

Another point about user-friendliness: Isn't it nice to have all those function keys available? The Mac has no function keys. Switching resolutions is not a problem, either. It can be software-selected, as shown by the paint program, NEO-chrome, which comes bundled with the computer. If you think that the ST method of switching resolutions is a quirk, then having to press Command-E every time you want to remove a disk on the Mac is a "QUIRK+."

Mr. Menconi made no comment on the ST's 640 by 400 monochrome screen or dual-resolution RGB monitor. He also did not mention that the system includes RS-232C, parallel, and DMA ports; a cartridge slot (for running Mac products faster than the Mac using the new Magic Sac emulator); or the MIDI ports. We had to laugh when we read the statement "Unfortunately, relatively little software is available that really makes use of the windows, menus, and icons so characteristic of TOS." While we agree that a good word processor has been a long time coming, most other areas have been taken care of quite well. Look at the public domain CP/M-Z80 emulator put out by Atari; the Macintosh emulator, Magic Sac; and the public domain emulators for the Apple II, Commodore 64, and Atari 8-bit software. There's also DEGAS Elite, a powerful paint program; GEM versions of VIP Professional and dBMAN; and powerful MIDI software.

The 40-folder limit per disk is not as Mr. Menconi presents it. You can have as many folders on a disk as you want, but, in the version of TOS he looked at, if you access more than 40 folders between system resets, you risk a directory error. However, some of us have ignored this precaution for as long as we've owned our STs, and no dire consequences have been reported. One last note: The Esc key does not update the screen; it only updates the current working window.

All in all, many people who are looking for a good, inexpensive computer with the advanced characteristics of the ST may be misled by this review.

Miami Valley Atari Computer Enthusiasts (MVACE)
Huber Heights, OH

Thanks for your feedback on the review. I'd like to clarify some points you brought out, however. I thought it appropriate to briefly contrast the ST with the Macin-

continued

tosh, a major computer that has a similar user interface. It was not my intention to do a thorough comparison.

The graphics resolution, ports, and cartridge slot were all mentioned in the article or the text box. Since all this information was gone over in great detail in the Atari 1040ST Product Preview (March 1986 BYTE), I thought there was no need to repeat it in the review.

When I wrote the review, only about 20 percent of the software available made use of menus, icons, and windows. I am happy to report that this figure has been climbing steadily since then. The specific software products you mention either don't use menus and windows or simply weren't available at the time.

—Dave Menconi

53 Dot-Matrix Printers

I just had to write to express my appreciation for the review entitled "State of the Art in Dot-Matrix Impact Printers" by Jane Morrill Tazelaar and George A. Stewart (April). What a thorough analysis! This one review was worth the price of a year's subscription and is a great service to customers and vendors.

But I can't for the life of me figure out where you got the figures for sound levels in the graphics mode. Does the Department of Defense know about Radio Shack's DMP 130? A level of 583 dB is about 7 on the Richter scale.

Walter Clark
Fullerton, CA

Playing the Odds

Mr. Carlisle's letter in the March issue reminded me of another speed-up method I came up with while exploring the Mandelbrot set.

The idea is to exploit the area-coherence of the drawing—namely, the fact that it consists of large areas of constant color. If, for example, a pixel is painted red, then its immediate neighbors are likely to be red, too.

The algorithm regards the pixels of the drawing area as two interleaved groups (A and B), analogous to the black and white squares on a chessboard. Note that each pixel in group B is surrounded by four pixels from group A.

Phase 1 of the algorithm paints each pixel in group A using the regular iterations loop. Phase 2 paints each pixel in group B according to the colors of its four surrounding neighbors. If all four neighbors are of the same color, then the pixel receives that color. Otherwise, the pixel's color is determined the hard way—by the regular iteration loop.

Recurring trials with various parts of the Mandelbrot set indicate close to 50 percent reduction in run time. This improvement is due to the fact that very few pixels in group B lie close to the border between two colors. Consequently, the iterations loop has to be entered very few times during the second phase.

The price to be paid for increased speed is decreased accuracy. During phase 2, a pixel might receive the wrong color. Such errors, however, are hardly noticeable, because they can only occur in areas of the drawing where feature size is in the order of magnitude of two pixels or less; and even in these areas, the probability of a given pixel being painted incorrectly is only $(n-1)/n^4$, where n is the number of distinct colors used in the drawing. On my microcomputer, using 16 colors, this is less than 0.03 percent.

If the pixels in group B are processed in raster order, then each pixel in its turn has *six* painted neighbors. The colors of all six may be compared, to reduce the chances of error even further.

Ofer Faigon
Tel Aviv, Israel

The check for repeating values that Mr. Carlisle mentioned in the March issue will indeed speed up calculations for points that lie within the Mandelbrot set. However, it adds some overhead to *each* iteration, whether or not the point is in the set. This overhead is not worth it for most plots, because people tend to want to see areas that are dominated with points that do not lie in the set.

Mr. Chi's point on the magnitude of the cutoff (also in the March Letters section) requires some clarification. We agree that there is no magic cutoff, and 256 will work for initial explorations at low magnifications. However, at higher magnifications a larger number is often necessary. We have seen plots where a cutoff of 6000 or more significantly improves the picture.

Regarding speeding up the calculations: If you have the 8087 chip, we suggest that you program in assembler, use all eight registers, and go back to memory only when necessary. Also, 16 bits will not be enough for serious exploration—we suggest 32 bits or more. Mr. Chi's comment regarding fixed-point math is otherwise excellent.

Mark W. Bolme
Bellevue, WA

Perspective Check

In Kenneth Perry's article "Abstract Mathematical Art" (BYTE, December 1986), the following sentence caught my attention:

"These one-dimensional automata are 'mathematically irreducible'—there is no shortcut to determine whether a given

continued

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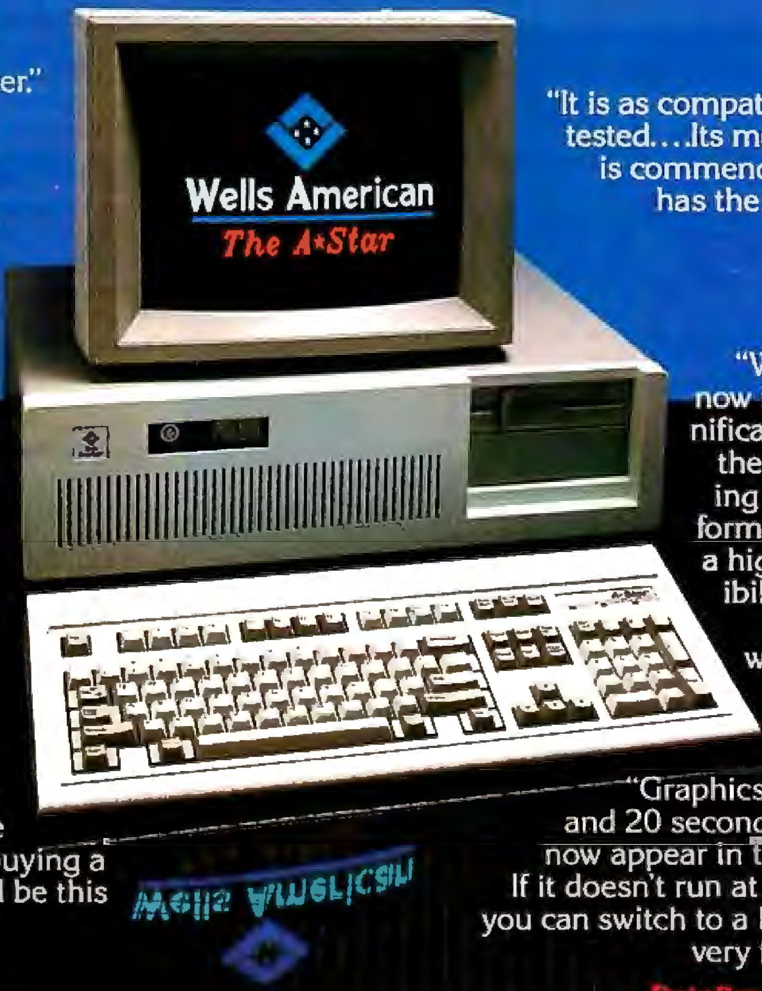

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I just wondered about the foundations for such a definitive statement. When I wrote to Mr. Perry about it, he kindly sent me a copy of Stephen Wolfram's article "Computer Software in Science and Mathematics" in the September 1984 *Scientific American*. Here are two excerpts from this reference:

"Universal computation has been proved for a simple two-dimensional cellular automaton. . . . It is *strongly suspected* that several one-dimensional automata are also universal computers"—that is, admit no mathematical shortcuts to decide their future behavior.

"*It is not yet known* how widespread the phenomenon of computational irreducibility is among cellular automata or among physical systems in general" (my italics in each quotation).

I think Mr. Perry's passage from these assertions to his conclusive statement illustrates two frequent mistakes. The first concerns elementary logic: The negation of the statement "All automata are reducible" is not "All automata are irreducible," but "There is at least one irreducible automaton."

The second mistake is perhaps not just a mistake, but (in my humble opinion) a mistaken attitude toward computers and their role in the process of scientific development. It is true that many physical problems presently escape our comprehension. It is also true that computer simulation greatly enhances our inside view of these problems. But please, don't confuse ignorance with impossibility; don't confuse computer simulation with theoretical thinking and research; and most important of all, don't deny from the outset the possibilities of good old-fashioned brainwork. Maybe, after all, what these last years of our century lack is not better mainframes, but better brains. Maybe after all we *are* now playing a trivial game.

Ricardo Slutzki
Buenos Aires, Argentina

Fantasy Not Needed

I have ambivalent feelings about the article "The Potential for Interactive Technology" by Alfred Bork (February BYTE). I agree totally with his feeling that our schools need tremendous improvement and that we must be willing to spend money to get that improvement.

Education is an investment in national security, and conservatives are dreadfully inconsistent when they oppose adequate funding for education. I have observed in some of my acquaintances the lack of respect for teachers that Mr. Bork mentions.

However, Mr. Bork lost my sympathy when he brought in the science fiction concept of computers monitoring students' brain waves to ascertain their level of understanding. He might as well have brought in the equally fantastic notion of computers directly manipulating students' brain waves so as to impart learning without effort on the students' part! These concepts have no place in a serious discussion of how to improve our educational system.

Computers are a part of society, and will become more so as they become more powerful and less expensive. They have a place in schools, both as a learning aid and because students can no longer be considered truly literate without at least a basic understanding of computers.

But I have a big quarrel with anyone

continued

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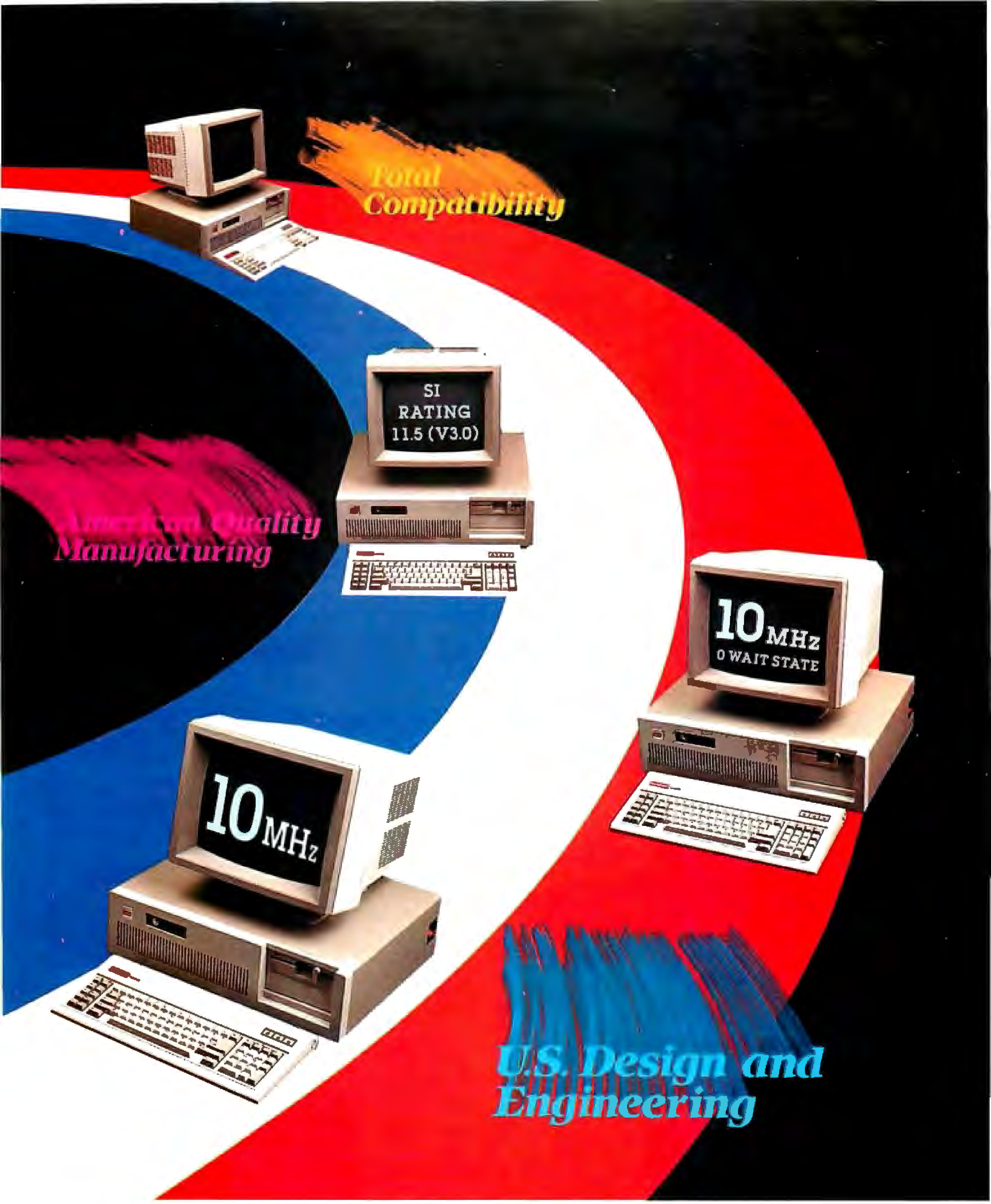
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who thinks that computers can replace teachers. There is a lot of talk about "interactive" educational software. The computer asks a question, the student attempts to answer it, and that answer determines the computer's next move: perhaps another question, perhaps more instruction. At its worst, it is an electronic "flash card"—an inappropriate use of a still-expensive technology. At its best, it is a useful study aid.

But perhaps the most important part of education is *intelligent criticism.* This may come from parents or peers, but in the school it is the particular job of the teacher. The best math teacher I ever had was the one who stressed that the method you used to approach a problem was as important as the answer. Application of method is easily learned by rote (this is an appropriate place for the computer), but before you can apply method you must have some method to apply.

The assessment of how a student is approaching a problem is a task that requires intelligence. Directing the student from his present incomplete understanding toward a more comprehensive understanding is also a task that requires intelligence. I leave it to Mr. Bork's futurists to speculate about intelligent computers 20 years from now. Today we have very sophisticated expert systems, but nothing that can remotely be called artificial intelligence or even the germ of artificial intelligence. And with no sort of real artificial intelligence yet, and none on the horizon, I think it is irresponsible to base our plans for education on concepts requiring artificial intelligence.

A computer can tell whether you have given the right answer, but it cannot tell whether your wrong answer was due to careless arithmetic or to use of the wrong formula. A computer cannot grade an essay on Hegel's dialectics. I fear that inappropriate use of computers may lead us away from significant areas of thought ("What is the significance of Dostoevsky to Russian literature?") and toward trivial ones ("When did Dostoevsky write *The Idiot*?"). A computer cannot grade your response to the first question, but it can grade your response to the second. We are in danger of letting the limitations of the computer determine the direction of our educational system.

However, there *are* programs that are truly interactive. They let students see the results of their logic and require them to work through their mistakes. Students must try to understand *why* their mistakes do not work. In the process of completing their task, they gain insight into the nature of the task. It is of this type of insight that real intelligence is made.

The "educational programs" I am speaking of here are programming languages. I assert that the most efficient use of the computer in school is to allow students to write their own programs. Programming allows students to pick their level of difficulty. The severely retarded student can learn to write a "Hello world!" program. The brilliant student can write a relational database program. The rest of us can write something in between. Programming at any level requires you to think, not just to answer questions, and that is what real education requires.

Dan Schechter
Amenia, North Dakota

Export Controls

The discussion of U.S. export controls for personal computers (November 1986 BYTE and Letters in the February issue) missed one point: This sort of interference is not restricted to Soviet bloc countries. While living in Botswana, a country friendly to the U.S., I bought a Zenith 150 series PC (a standard 8088 machine)

continued

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through a U.S. mail-order firm and arranged to have it shipped to me. Imagine my surprise when I learned that it had been seized by U.S. Customs, who held it for more than a month while trying to determine whether exporting it would be a violation of U.S. law protecting high technology.

I was also advised that, should the decision go against me, I would face fines and possible criminal prosecution. The final straw came when the computer was stolen, from a bonded U.S. Customs warehouse.

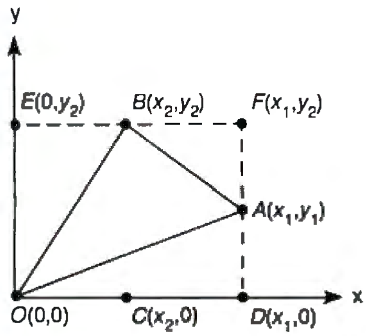
I received an insurance check several months later, and in the meantime I bought the same Zenith from a local dealer, for the same price, with an RGB monitor thrown in for good measure. Apparently large companies export under blanket licenses, however, individuals are forced to prove that their particular machine poses no national security threat.

The Customs Service has more important things to do than investigate off-the-shelf personal computers that are available around the world and whose components were very likely not even manufactured in the U.S.

Fred Swartzendruger
Alexandria, VA

Calculating Areas

Since I have just recently been involved in providing assistance in calculating areas, I read with interest the article "Calculating the Area of an Irregular Shape," by Stolk and Ettershank (February BYTE). Readers interested in this subject might find the following analysis useful. To adapt my application solutions to those of Stolk and Ettershank for continuity, add two more coordinates (E and F) to figure 2a in the Stolk and Ettershank article.



This method may provide a more general solution analysis than the Stolk and Ettershank approach, because it doesn't necessarily involve overlapping areas. The revised figure shows that Area(OAB) may now be described as follows:

$$
\begin{aligned}
\text{Area}(OAB) &= \text{Area}(OEFD) - \text{Area}(OEB) \\
&\quad - \text{Area}(BFA) - \text{Area}(OAD) \\
&= x_1y_2 - x_2y_2/2 - (x_1-x_2)(y_2-y_1)/2 \\
&\quad - x_1y_1/2 \\
&= x_1y_2 - x_2y_2/2 - (x_1y_2 - x_1y_1 - x_2y_2 \\
&\quad + x_2y_1)/2 - x_1y_1/2 \\
&= (x_1y_2 - x_2y_1)/2.
\end{aligned}
$$

Richard L. Messeder
San Clemente, CA

No Easy Answers

I am a computer store manager in Philadelphia (so much for your theory that computer store managers don't read BYTE), and I really take offense at the prevailing attitude toward the retail computer business.

Let me tell you what a typical day is like. First the phone rings with a question about software errors. The caller has no idea what software package she's using, and she purchased the hardware and software from another vendor. Then someone walks in who has no idea about computer equipment, and we spend an hour educating him only to find that he can't

continued

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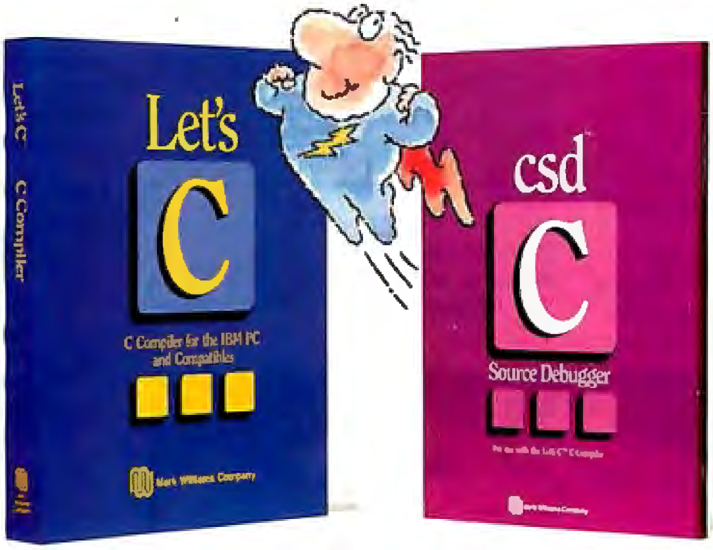

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"Let's C is an inexpensive, high-quality programming package... with all the tools you will need to create applications."
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"The performance and documentation of the $75 Let's C compiler rival those of C compilers for the PC currently being sold for $500...highly recommended..."
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Turbo C: **3.89** (As advertised)

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There are no easy answers, but one thing is certain: As margins get smaller and smaller, and as retailers must continue to discount to stay in business, we will have less and less money to pay experienced computer salespeople.

Lee Nelson
Philadelphia, PA

FIXES

Option Update

We stated in the December 1986 What's New section (page 29) that NEC's MultiSpeed portable computer has as options two external 5¼-inch disk drives. NEC informs us that this is incorrect. The machine "does not need 5¼-inch options because it has a floppy disk transfer port which allows for . . . file transfer from desktop to MultiSpeed and vice versa," NEC says. We apologize for the mistake.

Washington, as in Seattle

Thanks for including notice of our symposium in the Letters section of the March issue. There is, however, an error to be corrected. The letter stated that the symposium will be held in Washington, D.C. Actually, it will take place in Seattle, Washington, on July 12, 1987, the day before the AAAI conference.

Douglas Schuler
Computer Professionals for Social Responsibility
Seattle, WA

PAL Fixes

Robert Freedman writes to inform us that his article "A PAL Programmer" (January BYTE) requires these corrections:

page 266, Parts List:
Sprague parts are UCN-, not UNC- as shown.

page 271, Figure 3:
UCN5895A pin 6 should be labeled P13, not P3.
TREFF goes to common pin of 1.0K SIP. +5V goes to pin 2.

page 273, Figure 5:
Upper right: 5.11K resistor is labeled 10 REF on both ends. Lower end should be labeled 10V REF.
Lower right: LS138 should be LS251.
2.5V REF goes to LM339 pin 10.
10V REF goes to LM339 pin 8.
TEST goes to LM339 pins 9 and 11.
Top LS273, pin 1 & /RESET should not be grounded.

page 274, Figure 6:
LS259, data input, pin 13, should go to D0.
LS390 pin 14 /CLR should be connected to GND.
Bubble missing on 7406 pin 4.
Pin 11 of PAL-2 (16R8) must be connected to GND.

page 276, Listing 1:
Equation for SHD2 was omitted:
SHD2 = SD2 & !SD0 & !SD1.
Table 2: 109H: output /ENAB is missing.

page 278, Listing 3:
In pin list, EVCC should be active high—that is, remove ! from !EVCC.

Compatibility Resolved

According to the manufacturer, the GTX-100R 1200-bps security modem from A-O Electronics is not Hayes-compatible, as reported in March (page 32). ■

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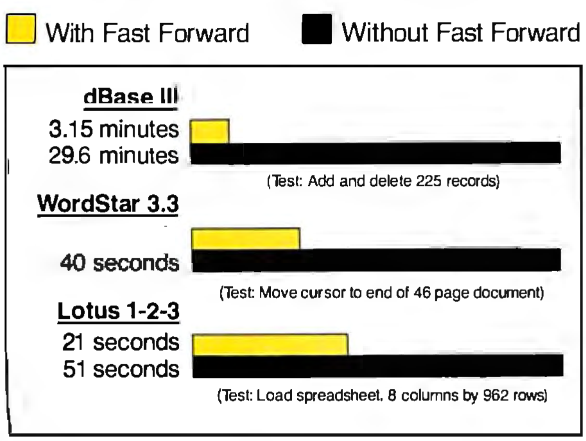

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Inquiry 183

CHAOS MANOR MAIL

Conducted by Jerry Pournelle

Amiga Defense Redux

[Editor's note: *In the March Chaos Manor Mail, Jerry responded to a letter from Warren Block that defended the Amiga as a programming environment and blamed software problems on developers. Mr. Block had included a selection of public domain programs on an Amiga disk that refused to work.*]

Dear Jerry,

Here we go again! I had finished putting that disk together at about 3 a.m., and I forgot to include a note telling you to disconnect any external drive before using it. Unplug your external drive and try the disk again. I think you'll like some of those programs a lot.

The problem was that one program (the Mandelbrot program) expects two disk drives. Since I wasn't sure that you had two drives, I used the Assign command to make the Amiga look in a directory on the disk instead of an external drive (called "df1:" by the system).

I don't have an external drive and didn't know this wouldn't work on a two-drive Amiga. As a result, the system gave an error message and quit. (As for ease of use, would MS-DOS handle an error in the AUTOEXEC.BAT file any better?)

So, I am guilty of the same error as those programmers I accused of being lazy or careless. Ouch. I do have an excuse, though: I didn't have any way to test that disk on a two-drive computer.

As for your point that the Amiga may be harder to program than the Atari, I can't say for sure—I don't have an ST. But keep in mind that programmers have been using the ST for a while longer than the Amiga (I'm told it was released in Europe a year earlier than in the U.S.), and it has a less sophisticated operating system—no multitasking, printer support is left up to the individual program, etc. In such a system, programmers can more easily get away with "antisocial activities" that a more advanced OS would choke on. In other words, the Amiga has not yet had a chance to reach the same developmental stage as the ST.

In the meantime, version 1.2 of the Amiga operating system is out. This release fixes the problems of 1.1, and third-party software has begun to appear with real speed.

Warren Block
Chadron, NE

I pretty well agree on all points; and now that the Amiga 2000, with a PC bus and 8086 chip, is out, I expect to see even more attention paid to the Amiga.

I confess I had figured out what happened before I had your letter printed, but it seemed to illustrate my point rather well—that the Amiga doesn't generally recover gracefully from a lot of errors.

With MS-DOS, you can interrupt the execution of the AUTOEXEC.BAT program, and often it merely ignores errors anyway. Of course, it doesn't do all the Amiga does. —Jerry

Sold on CP/M

Dear Jerry,

Thank you very much for the addresses for CP/M software in the December 1986 Chaos Manor Mail. Regarding the letter from R. Scott Truesdell, I'm glad to see another one has learned the benefits of the SB180. I've been running one almost since Ciarcia's articles appeared. It's a wonderful little beast, with two 5¼-inch drives, two 8-inch drives, and a 40-megabyte hard disk drive on it. I fully agree with you that nothing is truly backed up until it's on 8-inch disks.

I have several clients running CP/M on S-100 systems, and I've converted a couple of them to ZDOS. I've also converted a couple from IBM to the SB180. Let's face it, the IBM PC is far too slow, and PC-DOS is a nightmare for any serious or time-consuming work. I guess the reason so many go the IBM route is that it takes little intelligence to plug in a box.

Like Truesdell, I have too much invested (approximately $60,000) in CP/M and SB180 software to even think of going with IBM, even if I could afford the waste of time caused by its slow operating system. Any time I have to use an IBM PC at a client's office, I nearly go nuts waiting for it to catch up to me. If you haven't switched to ZDOS, may I seriously suggest you do? It's a whole new world from CP/M: faster, more efficient, and far more labor-saving.

John T. Linnell
Etobicoke, Ontario, Canada

Well, thanks. I have used ZDOS on the Z-100, and I agree, it's fast; and of course the Z-100 has 8-inch drives. I

continued

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think that if I didn't do this column, and thus have some need for playing about with a lot *of stuff, I could have been happy with my Z-100 with CP/M and ZDOS, from the time I got the machine until now. Indeed, we have some upgrade kits for the Z-100 that I'm about to install.*

CP/M isn't dead. It isn't growing as fast as the other systems, but that could change now that Concurrent DOS 5.0 is shipping.—Jerry

Dear Jerry,

In previous columns you have mentioned "The Pournelle User's Guide Series." My local bookstores do not have any of the books in this series, and after trying for three months they have still been unable to get them. (Maybe being in the wilds of New Mexico has something to do with this.)

This morning I called Simon and Schuster, at (800) 223-2348, and ordered the series. (They knew all about the books.) Maybe this will help other readers who are having trouble finding these excellent books.

I have long thought about getting a portable laptop but could not justify the cost (including the necessary accessories) of the available systems. I finally purchased an Epson Geneva PX-8 system (including the Epson P-80 portable thermal printer) for $430.

The Geneva weighs 8 pounds. With the Multi-Unit (64K-byte RAM disk and 300-baud auto-answer, auto-dial modem) and MicroPro Portable WordStar in ROM, it makes a fine portable word-processing system. The Geneva also comes with MicroPro Portable Calc Spreadsheet, Portable Scheduler, Microsoft BASIC, and (to me the best feature) CP/M, all in ROM.

Most of the public domain CP/M programs run as is or have been rewritten to run on the Geneva's 8-line by 80-character screen (reasonably legible even in poor light). I still need the 12 pounds of documentation, excellent by the way, that came with the system until I learn the programs and CP/M.

The built-in microcassette drive will save files up to 50K bytes, but it takes forever. The addition of Epson's PF-10 3½-inch disk drive, Traveling Software's Traveler's Pak (appointment, expense, and time manager) from DAK Industries Inc., and Wordpak (Spellguard, Footnote, Documate, and Grammatick) makes the Geneva a very powerful and complete portable system.

I can now appreciate your love of a laptop and the utility of the CP/M system.

I don't believe I have seen FOG (First Osborne Group, P.O. Box 3474, Daly City, CA 94015, (415) 755-2000) mentioned in your column. This group publishes the FOGHORN, a monthly CP/M newsletter supporting Osborne and most other CP/M computers. Readers using CP/M may find it helpful.

CP/M is still very much alive.

Webb V. Turner Jr.
Las Cruces, NM

P.S. There is only a serial printer port on the PX-8, and my NEC printer is parallel only. I have now purchased an MPI-99 printer (because of your recommendation and the super close-out price from Heath) to connect to the serial printer port of the PX-8: It is a strange and wonderful printer!

Things flow *in micro land. I haven't written about MPI printers in a long time. They have lots of good features but have to some extent been overtaken by many others. Still, if you can get one cheap, I'd grab it. We still use our Sprinter for travel.*

Glad to hear about the Epson Geneva. I've never actually seen one, strange to say.—Jerry ■

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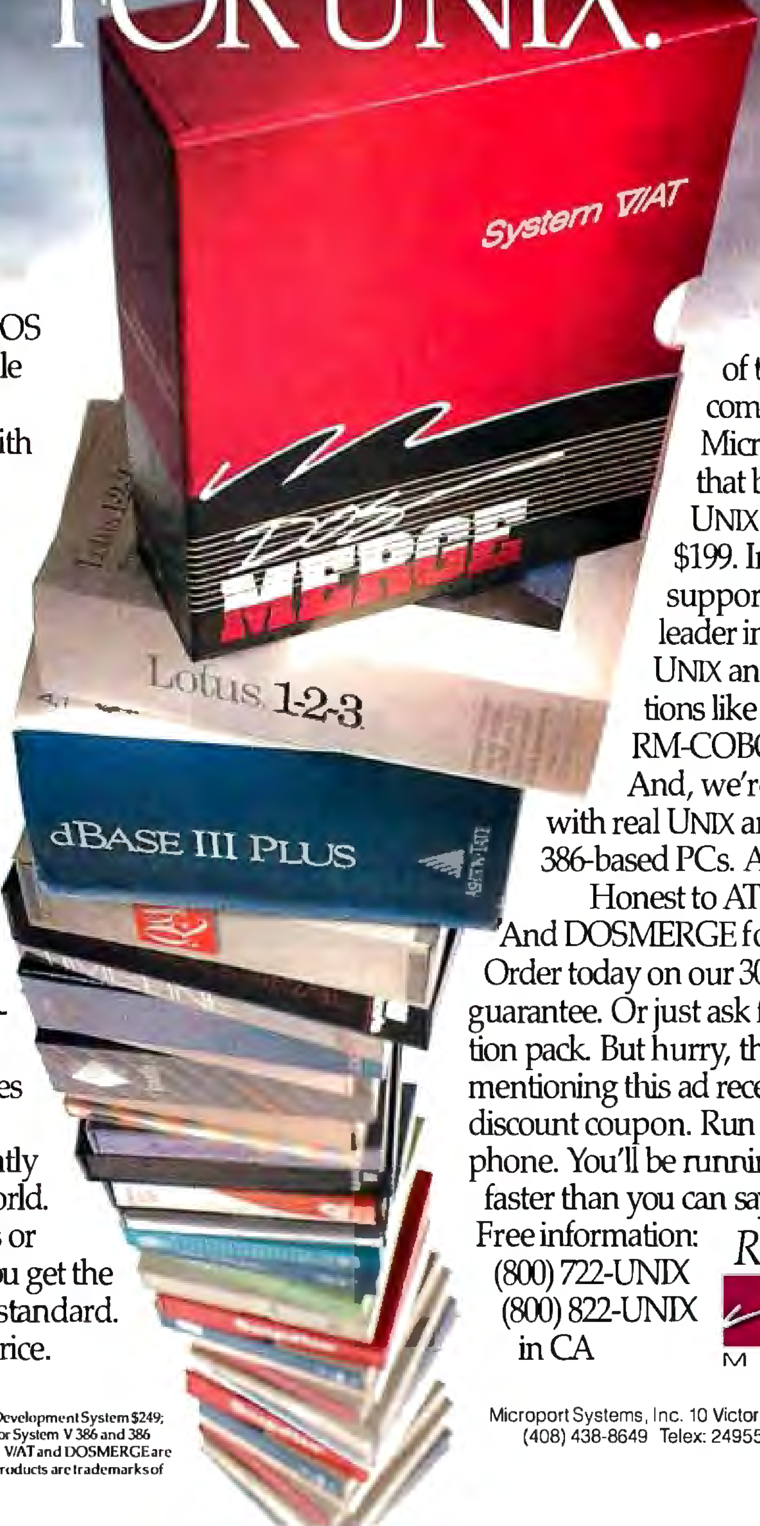

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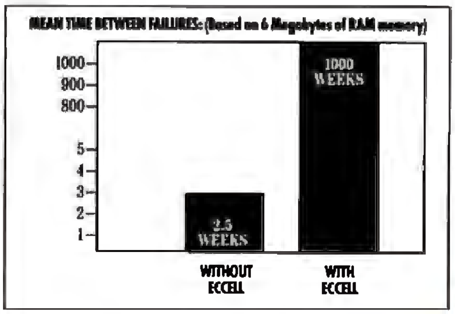

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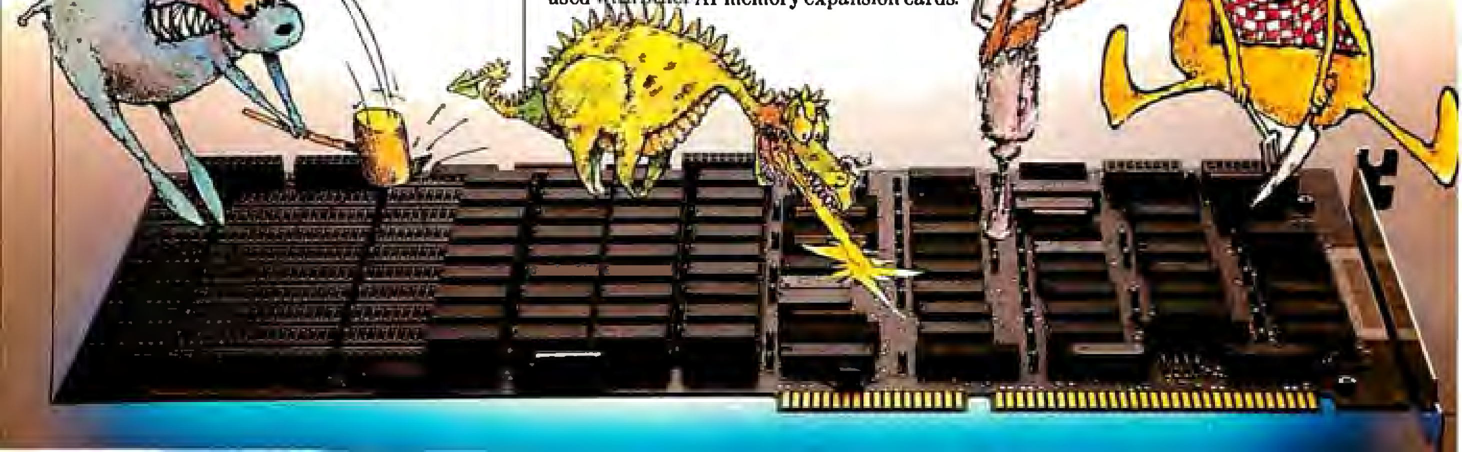


MICROBYTES

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

Planar Prototypes Multicolor EL Displays

Planar Systems (Beaverton, OR) has developed prototypes of 5-inch, 320- by 240-pixel, multicolor electroluminescent (EL) displays. Planar engineering manager Brian Dolinar told Microbytes that although the full-color subsystems will be used in environmentally harsh military applications as early as 1990, commercial displays won't be available until at least 1994. The prototypes provide full RGB video and can produce displays with pattern red, green, and blue phosphor dots or in a stacked color dot structure; they can also support from four to eight gray levels, Planar said.

In general, EL displays, which are made by applying thin films of phosphor onto glass substrates, are characterized by their thin profile, high shock resistance, high contrast and resolution, and low power requirements. Additionally, EL displays interface much like raster CRT displays, enabling hardware designers to use standard display controllers. Power requirements for EL units are typically about 2 watts for the display itself and 14 W for electronic overhead. According to Dolinar, Planar's goal is to have total power requirements for the multicolor EL unit down to a maximum of 10 W. EL displays used in jet fighters routinely operate in temperature ranges from −55 degrees Celsius to +125 degrees C and withstand shocks and vibrations in the hundreds of Gs.

Monochrome EL displays are currently used in portable PCs (Data General's, for example) as well as in industrial control and military settings. Planar previously fabricated two-color (red and green) EL displays for military applications.

Berkeley Unix Going Through Changes

Significant changes to Berkeley Unix are underway, say computer scientists at the University of California's Berkeley campus, but it will probably be a couple of years before users see those changes fully implemented. Marshall McKusick, a scientist with UCB's Computer Systems Research Group, told Microbytes that three major areas of Unix 4.3 BSD are undergoing development: the virtual memory system, the file system interface, and the protocol layering interface.

According to McKusick, "the file system is pretty much operational now," and, because the work is being completed "serially," modifications will be released incrementally. This file system interface uses the 4.3 BSD name-lookup calling convention, but otherwise resembles Sun Microsystems' Virtual File System (VFS) interface.

Future versions of Berkeley Unix, said McKusick, who is working with Michael Karels on the project, will "support virtual memory space at least as great as the sum of sizes of physical memory plus swap space." Additionally, processes will probably be allowed to map files and device memory into their address spaces and to share memory with other processes.

The protocol layering interface McKusick and Karels are working on will be based on the simple stackable-line discipline of the Eighth Edition Unix rather than the Streams implementation of System V, release 3. McKusick and Karels plan to implement a socket interface rather than a character device interface, and protocols in the kernel will handle the demultiplexing.

McKusick added that "a major change we have made is that we are basing our releases on hardware made by Computer Consoles Inc. We did that because DEC [4.3 BSD is based on Digital Equipment Corp. hardware] was getting to the point where they felt they were competing with us. It was getting difficult to get documentation and so on. Our next beta release will likely be based on CCI." McKusick said that "we are making it [Unix] more portable by doing this. . . . By going to completely different hardware, we've had to face a number of issues that manufacturers have had to face all along."

continued

Nanobytes

Notables and quotables from **the West Coast Computer Faire:** While **Intel** was telling Faire-goers that software for its 80386 is on the way, **Motorola** was claiming its 68020 is the superior processor, partially because of its binary upward compatibility. "The Intel compatibility problem is a nightmare," said Motorola's Kevin Meyer. Someone from Apple Computer said the linear address space of the 68000 series is better suited to bit-mapped graphics and memory-mapped I/O than is the segmented address space offered by Intel. . . . Philip Gill, contributing editor for *Informationweek*, told a session on **Unix** that some users of Xenix on 386-based machines are claiming performance twice as fast, and half as costly, as that of a minicomputer. Brian Boyle, director of research at the Novon Research Group, said Unix on 386 machines will be like an automobile's electrical system: You know it's there, but you have little interaction with it. . . . **Dan Bricklin** of VisiCalc fame said the development of 16-megabit RAM chips could usher in an era of diskless computers; drives will be junked because of their slowness. . . . At one session, panelists agreed that, for good or bad, **Pascal** programmers will turn increasingly to other languages, primarily **Modula-2**, to build more powerful applications. They said Pascal has remained an educational tool and has not moved into programming environments dominated by C. . . . And if you've been waiting for a solution to all those **RAM-resident conflicts**, well, you've got some more waiting ahead. Without standards, panelists said, software houses can do little to keep their pop-ups

continued

from clashing. The panel members also concurred that RAM-resident software is very tough to implement in multitasking environments because the status of RAM is always changing, which leaves open the question of how these programs will fit in with the new multitasking operating systems. . . . At its springtime developers' conference, **Apple Computer** (Cupertino, CA) officials said it is interested in these types of products from third-party designers: lab instrumentation boards, industrial cards for process control, communication cards, sound and music peripherals, 68020 accelerator boards, graphics coprocessor cards, expansion cages, and multifunction cards. . . . **Information Storage** (Colorado Springs, CO) says it will bring out in the fourth quarter a WORM drive that stores between 480 and 550 megabytes on each side. . . . **Falcon Technology** (Glendale, CA) has brought out an instrument that measures five system parameters of 8088- and 8086-based machines. The Mipster ($495) consists of a probe that plugs into the microprocessor socket of the system being checked (and into which the system's processor is reinserted) and a seven-digit LED readout that displays the parameters. It measures machine speed, clock frequency, memory accesses, I/O accesses, and number of times the instruction stream queue is flushed. Probes for the 80286 and 80386 will be available later this year, a company executive said. . . . At the National Computer Graphics Association's annual show, **Cricket Software** (Philadelphia) was running a prototype of its Cricket Draw graphics package in color on a Macintosh II. The final release of the new version will support 256 simultaneous colors from a palette of 16 million, the company said, and will sell for $395. . . . **Commodore** (West Chester, PA) was showing its newest Amigas, the 2000 and the 500, at the NCGA conference; but the machines were adorned with little notes indicating that because they had not yet passed

continued

Programmers Debate Languages, "Corporate" Programming

Some of the micro industry's best-known programmers gathered recently in San Jose, CA, to talk about how they do what they do. Although the panel—consisting of Bob Carr, Andy Hertzfeld, Scott Kim, Charles Simonyi, Jaron Lanier, John Page, Jef Raskin, Peter Roizen, and John Warnock—did not discuss projects they are currently working on, they did discuss the future of programming languages and how programmers can survive in a corporate environment.

Hertzfeld (developer of the Macintosh operating system) and Carr (chief scientist for Framework-maker Ashton-Tate) said they prefer programming in assembly language. Roizen (developer of T/Maker) and Lanier (former Atari video game programmer) work with Pascal. But Simonyi (from the Microsoft group that has produced Multiplan, Word, and Excel) generally spoke for the group when he said that C is probably the only general-purpose language for most software development. "At Microsoft, we program only in C," he said. "C now and C forever."

Raskin, one of the creators of the Macintosh, pointed out, however, that certain programming tasks often require certain languages. This view was seconded by Carr, who said that the software marketplace will probably become fragmented, making it more exciting than the "homogeneous software environment we've seen over the past couple of years." That environment, he said, will have specialized vertical programs that may be written in specialized languages, perhaps even macro languages that are part of applications programs themselves.

The programmers debated the virtues of single-person programming versus "corporate" programming (in which a team of programmers produces a product). Hertzfeld bluntly stated, and Roizen and Kim (author of the book *Inversions*) concurred, that the best programs are written by a single person. Page (of Software Publishing and PFS fame) disagreed, however, saying it just isn't realistic for a large company to expect an individual to produce enough code to get a big product out in a timely fashion. Carr agreed, saying that the hundreds of worker-years it takes to build a program such as dBASE or Framework makes it impossible for a company to afford the luxury of "one programmer, one program." Warnock said Adobe has found that a three-person programming team is the most effective. "Two people isn't enough and four is too many. That third person in the group adds balance," the developer of PostScript said.

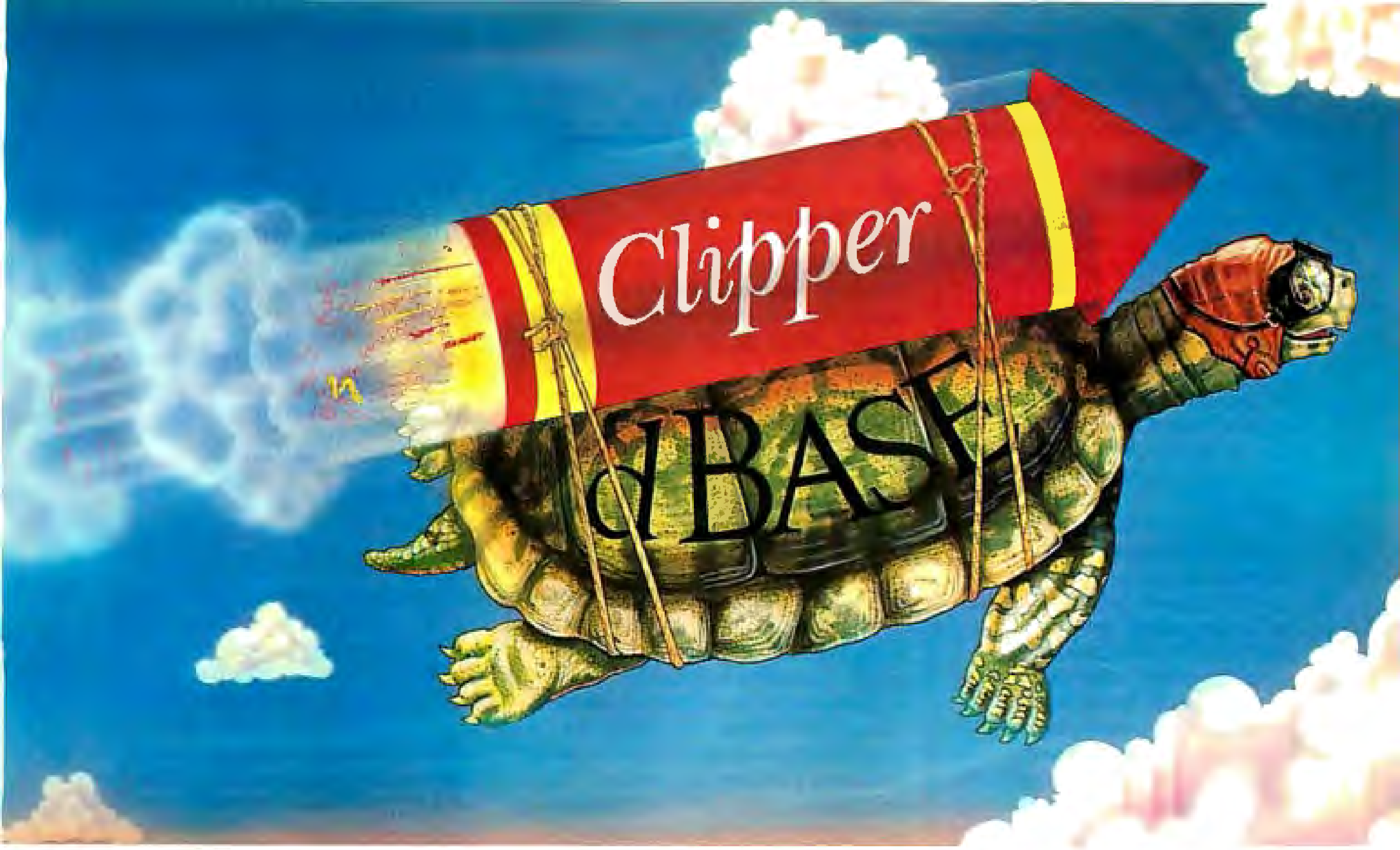
The panelists also disagreed about the increasing tendency among programmers to use third-party subroutine libraries. Both Carr and Page said they feel that off-the-shelf routines can save programmers both time and money. Hertzfeld countered by asking, "How can you care about your program if you use someone else's code?" He continued, "I consider myself an artist. If I were another kind of artist, a writer for instance, would it be right for me to go out and buy a paragraph here, a chapter there, and include them in my book? Would it still be mine?" Kim added that it usually takes him longer to read and understand another person's code than it does to write it himself in the first place. All the programmer panelists, however, said that over the years they had put together their own subroutine libraries, which they regularly use.

Optical Head Combines Hologram and Lasers; Could Mean Lower-Cost Optical Drives

An optical disk head combining holography and lasers has been developed by researchers at Pencom International (Santa Clara, CA). According to its inventor, Dr. Wai-Hon Lee, the technology could eliminate as many as nine common components (beam-shaping lens, toroidal lenses, wave plates, mirrors, etc.) from standard L-shaped optical heads, resulting in higher performance and lower costs for optical drive manufacturers and, ultimately, users. Lee explained that the reduced weight (6 grams, as compared to a standard of about 400 grams) of such a head will speed up disk access time by factors of 5 to 10.

Key to the design of the Pencom head, Lee said, is a hologram that serves as both the beam splitter and the focusing optic. Equally important, he said, is the combining of the focus detector and the laser in a single pack-

continued



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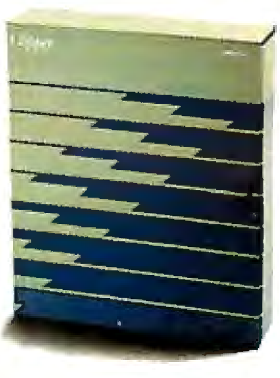

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FCC certification tests, they were not for sale. . . . **The Association of Electronic Cottagers** (Davis, CA) says the top 10 ways for making money at home with a computer are consulting, typesetting, bookkeeping, writing, entering and processing data, researching, word processing, custom programming, desktop publishing, and providing mailing lists. . . . At the "request" of the **National Security Agency, Versitron** (both of Washington, DC) canceled its "How Computer Security Can Be Compromised" seminar at the Interface '87 conference. Versitron was going to demonstrate how data can be stolen from a computer using passive listening techniques. . . . At that same conference, **Dataradio Corp.** (Atlanta) introduced a wireless modem capable of transmitting data over radio channels at as much as 9600 bits per second. The Dataradio Series 9600 is designed to replace leased phone lines or provide data circuits where dedicated lines are not available. . . . You won't be seeing this at your local video shop: **The Boston Computer Society** has produced a series of videotapes on creating software. "There are 14 seminars in the series," the BCS says. "Many are by 'gurus' of the industry who took time out from doing in order to teach and share code." The series sells for $350. Contact the BCS Software Engineering Forum, 59 Morseland Ave., Newton, MA 02159; or phone (617) 738-8230. . . . When asked at the West Coast Computer Faire to assess the impact of superconductors on new products at Apple, Steve Sakaman of that company said, "It took us a long time to put a fan in the Mac, so it might be a while before we put a refrigerator in it."

age. In Pencom's system, the laser beam passes on a straight line through a single collimating lens and then the hologram before focusing on the media. When the beam returns from the media, the hologram refracts the beam slightly, returning it to the tracking detector.

In general terms, a hologram is an interference pattern between two light beams. The pattern Lee developed is calculated and generated by a computer, then transferred to a semiconductor-like mask before being replicated onto a glass lens.

Currently, several companies are evaluating the Pencom head. Lee said he thinks optical drives that make use of the holographic-laser head may begin appearing in about six months.

Active-Matrix LCD Called the Display of the Future

Active-matrix liquid crystal displays will be the "the next evolutionary step" in display technology, said panelists at the West Coast Computer Faire recently. According to David Mentley, a display research analyst with DEM Associates (El Cerrito, CA), active-matrix LCDs have already been accepted by makers of small-screen, personal TVs and will be a driving force in developing the technology for computer displays. Mentley predicted that within the next year or so, we may even see "personal portable computers" that have the same 3-inch full-color screens now available for televisions.

Active-matrix technology is based on positioning a transistor and capacitor at each pixel on the screen. This enables full color at high resolution. It also eliminates commonly encountered multiplexing problems, because an entire line on the display can be turned on or off in less than 6 microseconds.

The biggest development problem with active-matrix panels is that engineers cannot yet build ICs that are large enough to power the displays. This explains why the 3-inch diagonal screens are the most commonly found: The IC must be the same size as the screen. The largest active-matrix prototype he has seen, said Mentley, is a 14-inch diagonal screen, although the largest acceptable screen is only 6 inches in diagonal. Recent advances in thin-film transistor technology, however, indicate that larger acceptable screens may be possible in the near future.

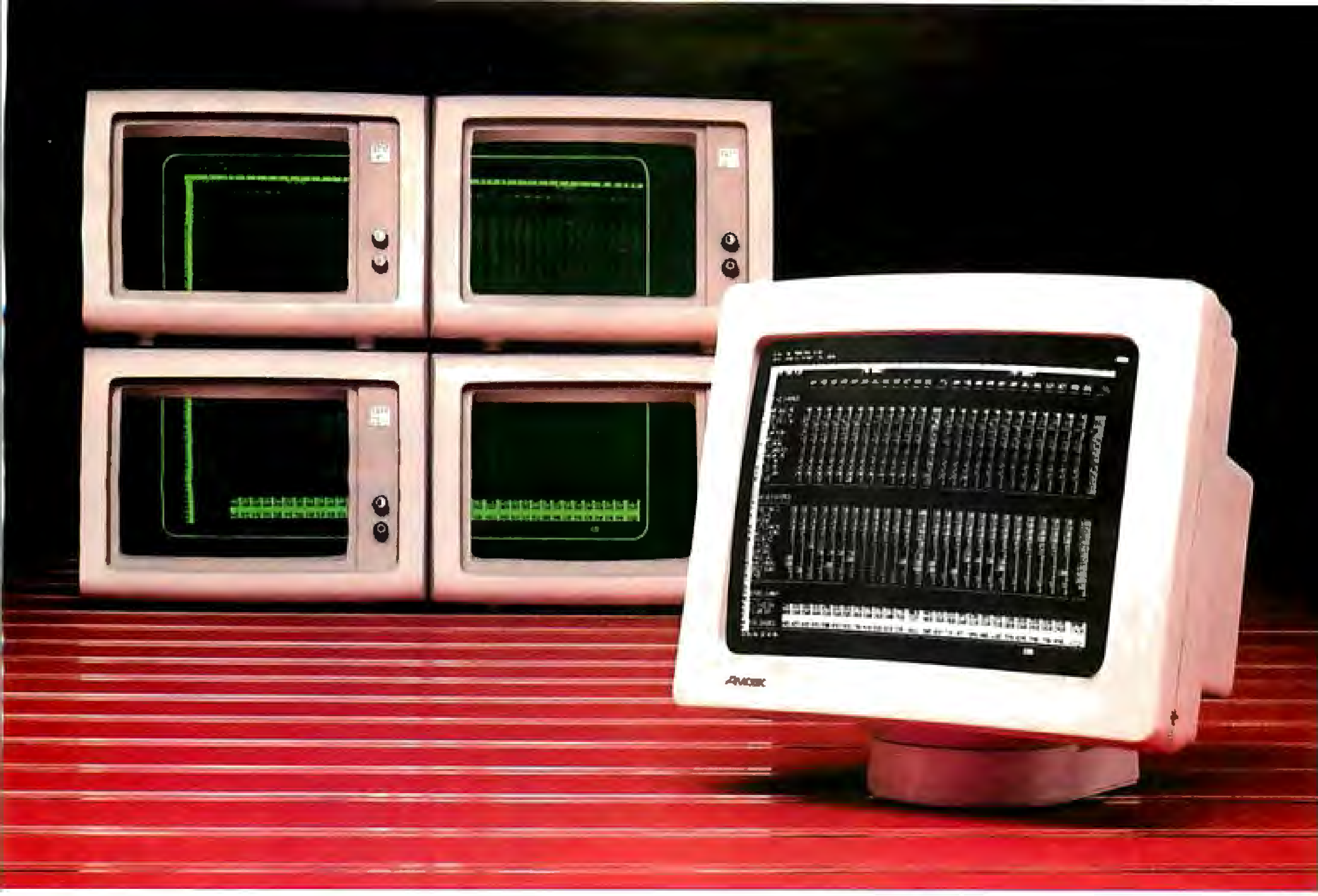
Mentley reported that several companies, including General Electric, Hitachi, IBM, Matsushita, NEC, Sharp, Toshiba, and Xerox, have very large active-matrix programs underway. Current manufacturing costs for active-matrix panels is about $10, Mentley said, with OEM prices around $85; he noted that the price of active-matrix LCD televisions has dropped to as low as $125. Mentley concluded by saying that costs of software drivers will be a factor in determining the eventual costs for PCs because active-matrix drivers cost more to develop than traditional LCD panels.

Device Controls Execution of Programs

Rainbow Technologies (Irvine, CA) has a new hardware key that developers can use to control access to as many as 10 software programs. The Software Sentinel-M has a clock/calendar that lets developers set individual time-outs; the internal counter can be set to monitor a certain number of program executions and then deinstall the program, which can be handy for applications such as software rental and trial usage. Company president Walter Straub said developers can "marry software to the hardware key" as an alternative to traditional copy protection.

The key hooks to the parallel port of IBM PCs and compatibles and runs under MS-DOS. Straub claimed the Sentinel-M's algorithm technique offers more security than designs based on serial number, fixed response, or returned-pulse methods. The Sentinel-M sells for $50 in quantities of 500 to 1000. According to the company, a model that plugs into a serial port is in the works.

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



It takes four of theirs to display the same spreadsheet as one Amdek 1280.

Now, Lotus 1-2-3 and Symphony can be even easier and quicker to run. Because Amdek's 1280 graphics subsystem displays up to four times more spreadsheet than a standard IBM monochrome or compatible monitor.

For incredibly vivid resolution, the Amdek system puts 1280 X 800 pixels on a big 15" white phospher CRT.

There are a total of 11 modes. What's more, the 1280 provides complete monochrome and color graphics compatibility.

Price? The Amdek 1280 monitor and video board cost only $999. So, if you work with Lotus, CAD or desktop publishing, Amdek's 1280 graphics subsystem is clearly your best buy.

The Amdek 1280 provides 1280(H) X 800(V) resolution with these software packages:

GENERAL PC SOFTWARE
Lotus 1-2-3
Symphony
PC-Paintbrush

DESKTOP PUBLISHING
AdvanTex
Ventura Publisher
PageMaker/PC
Frontpage
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Rim Systems
Compound Document Processor
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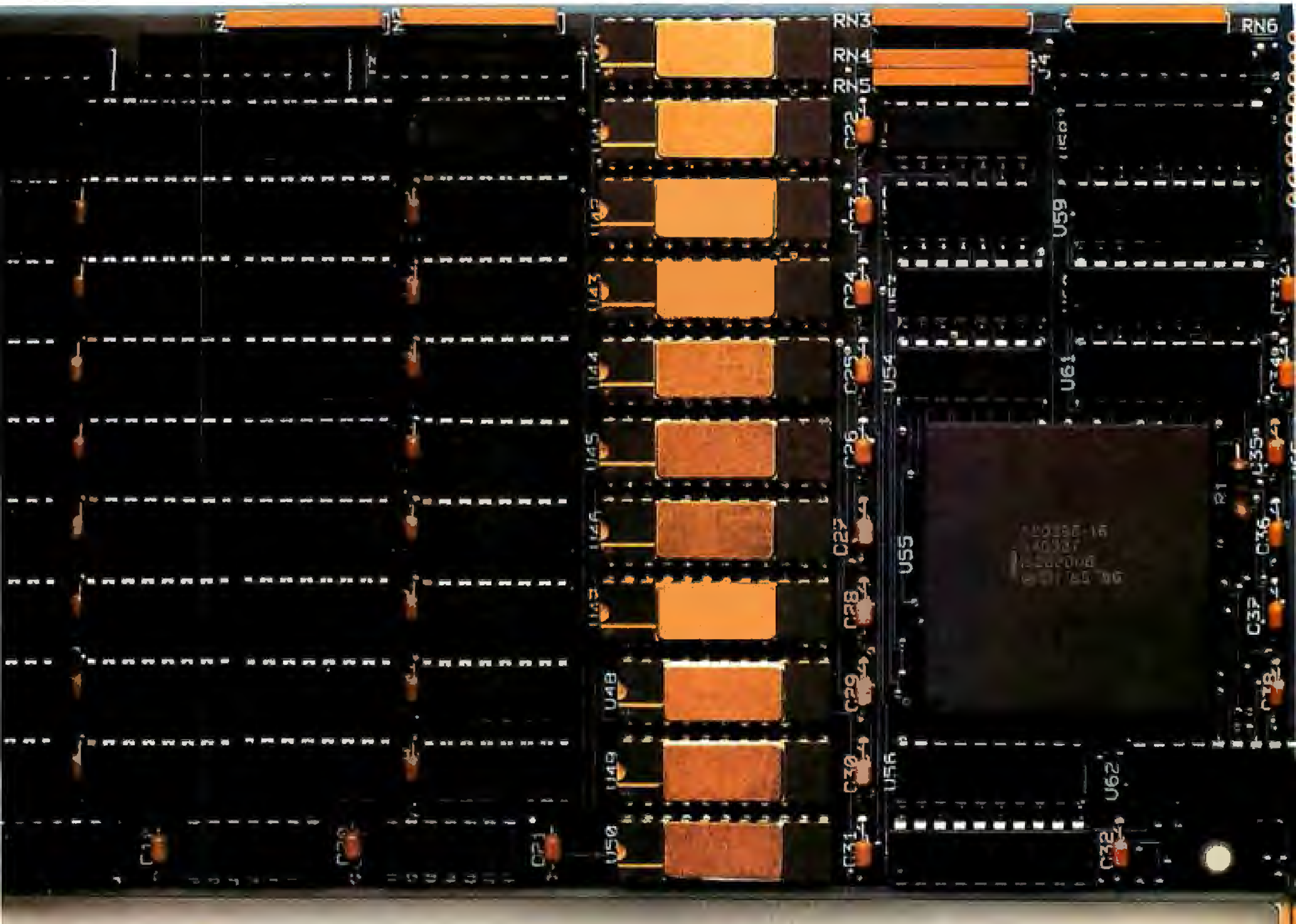
Inquiry 16

How to 386



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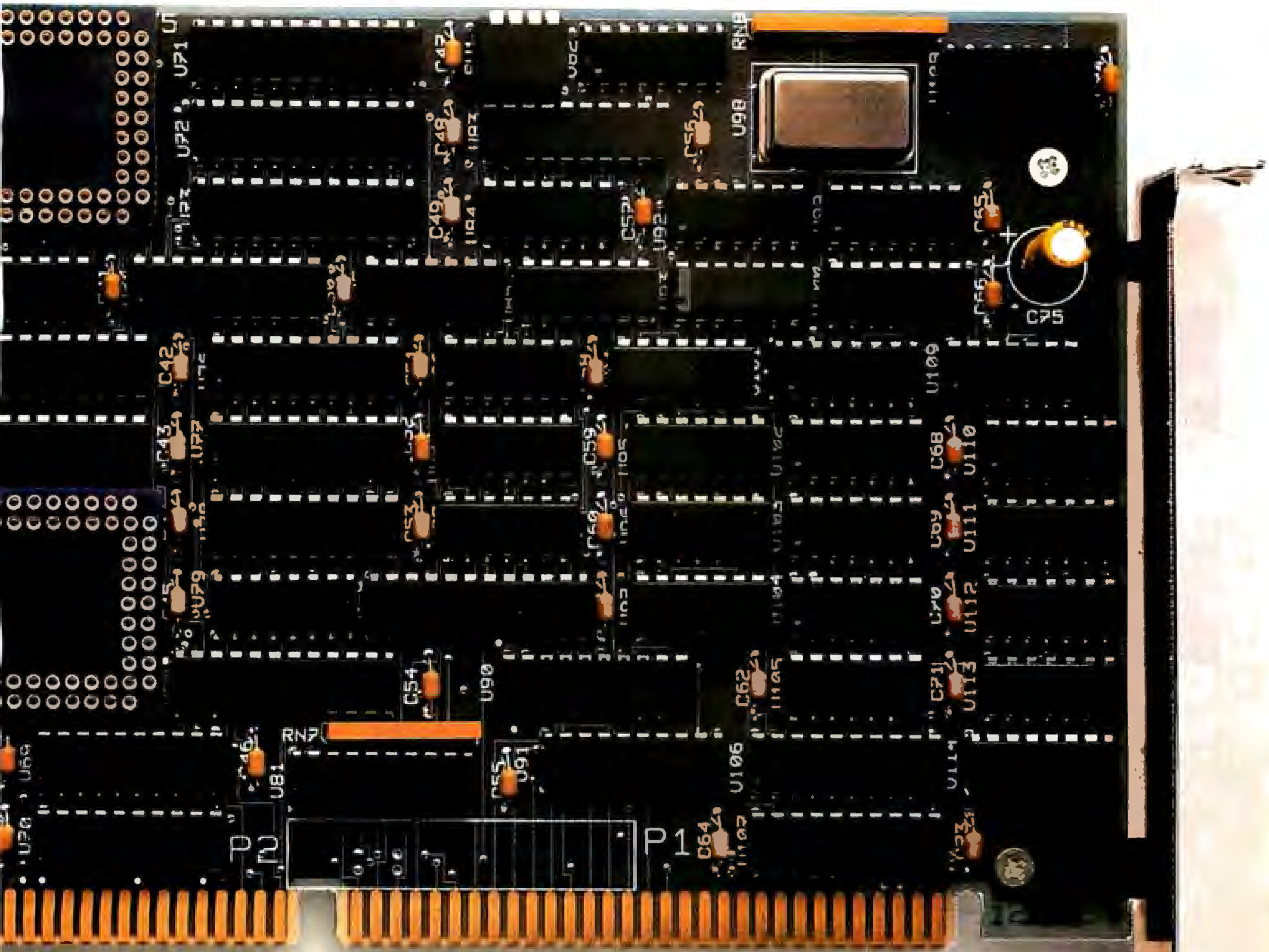

you can take advantage of exceptional multitasking capabilities. Like putting together a presentation while your computer is downloading data. (A slightly more efficient way of doing business.)

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WHAT'S NEW

Information from this month's most interesting press releases.

Tandon's 30-megabyte Personal Data Pac.

Shock-Proof Removable Hard Disk

Tandon's Personal Data Pac is a removable hard disk drive designed for easy transport and durability. Designed for the IBM PC and compatibles, the Pac is a 3½-inch dual-platter 30-megabyte hard disk drive in a hard plastic enclosure about the size of a full-height floppy disk drive. You can easily attach it to an external adapter that contains two slots for the new drives and a caching disk controller.

The Data Pac's drive heads are locked away from the media when not in use. Each pack weighs about 2.6 pounds and measures 2½ by 4¾ by 7 inches, for easy transport in a briefcase.

Tandon says that tests have shown that Pacs can withstand up to 300 Gs of force, (or a drop of 30 inches onto concrete) without losing data or breaking the plastic case.

The data transfer rate for Pacs is 7.5 megabits per second with a maximum access time of 50 milliseconds and average seek length of 100 ms. Each Personal Data Pac can be password-protected by using a special utility.

Price: $400; Ad-PAC 2 subsystem (holds two Data Pacs), $500.

Contact: Tandon Corp., 405 Science Dr., Moorpark, CA 93021, (805) 523-0340.

Inquiry 576.

Q&A for the 386

The database and word-processing program Q&A is now available for 80386-based systems. The 386 version takes advantage of the Lotus/Microsoft/Intel Expanded Memory System (LMI/EMS), letting you access memory above the DOS limit of 640K bytes. Symantec reports that the instruction set increases speed by 10 percent to 40 percent, and that the code size has decreased by about 20 percent. The original 8086 version of Q&A will run on 386-based systems, but without the increased speed and memory advantages of the 386 version.

Q&A requires an Intel 80386 microprocessor, 512K bytes of RAM, and MS-DOS version 3.0 or higher.

Price: $349.

Contact: Symantec Corp., 10201 Torre Ave., Cupertino, CA 95014, (408) 253-9600.

Inquiry 577.

Hand-Held Scanning

The Handscan is a mouse-like data-entry device that lets you enter portions of printed or typewritten documents directly into an applications program such as Lotus 1-2-3, dBASE III, Microsoft Word, R:base 5000, WordStar, or any program that accepts ASCII data. Working with proprietary memory-resident optical-character-recognition software, the Handscan recognizes more than 200 computer-generated or typewritten fonts. When you enter the font name into the computer, the Handscan displays the name of the recognized font on the screen.

The unit has five pushbuttons: one for reading data, and four for cursor movement that let you move around an applications program screen without having to use the keyboard cursor keys. The unit is programmable so that pressing combinations of two or three keys performs special operations unique to the application. You can also program a substitution table that will automatically enter a discrete character into the application when another specified character is read by the Handscan. This lets you perform functions such as removing commas from numbers or eliminating proportional spacing from text.

The manufacturer claims that the Handscan's error rate is less than one error for every 1300 characters scanned. The Handscan package consists of the scanner, a full-length interface card, and software. It runs on IBM PCs, ATs, and compatibles. A hard disk and 640K bytes of RAM are recommended.

Price: $649.95.

Contact: Saba Technologies Inc., 9300 Southwest Gemini Dr., Beaverton, OR 97005, (503) 222-7050.

Inquiry 578.

Ultra-Parallel 68020 Board

Systolic System's Model 481 is a VME-bus-compatible parallel numeric processor that's capable of full IEEE-P754 standard 32-bit, 64-bit, and 80-bit floating point computations. The board contains a single 68020 processor, four 68881 numeric coprocessors, and 256K bytes of 70-nanosecond RAM.

Using a 25-MHz system clock, the system executes 1.29 million 80-bit floating-point erations per second. Multiple 481 boards can be installed in VME-bus–compatible computers (such as the Macintosh II) for additional performance gains.

The Model 481 board performs nonlinear, transcendental, and trigonometric functions, and is well-suited for running simulations. A scientific software library of more than 400 commonly used subroutines is available in both FORTRAN and C.
Price: $4995.
Contact: Systolic Systems Inc., 1065 East Brokaw Rd., San Jose, CA 95131, (408) 286-0421.
Inquiry 579.

Ryan-McFarland's Development Tools

RM/Screens and RM/Forte are two new productivity tools from Ryan-McFarland that are designed to enhance program development.

RM/Forte is a file manager, compiler, linker, and debugger that is now packaged with version 2.4 of RM/FORTRAN, an ANSI-77 optimizing FORTRAN. Other enhancements to version 2.4 include a syntax-checking capability, a faster math-coprocessor library, and improved interlanguage communications. Its 8087/80287 emulator executes programs five times faster than earlier versions. It lets you handle mainframe-type floating-point arithmetic without installing an 8087/80287 coprocessor chip, but will take advantage of the chip, if you install one.

RM/Forte manages your program files, integrates several development tools into one operating environment, and simplifies the testing process. The project manager maintains information about all files in an RM/FORTRAN application, letting you track projects through all stages of development. The screen's project-status line shows you the number of files in a project, tells you whether an executable program exists, and reports what development task should occur next. From the screen you can select source files to edit, and you can edit them without having to refer to a printed copy of the listing. The listing file display shows the source code and the compiler diagnostic messages, including leading line numbers, embedded diagnostics, optional allocation maps and cross references, and compilation summaries.

Application screen generated by RM/Screens.

When your files are ready for compilation, RM/Forte invokes the RM/FORTRAN compiler at your request. You can tell it to compile only those files modified since the previous compilations, and you can specify the compiler options for each file.

RM/Forte sets up a link-control file before invoking the linker. The file contains all the commands needed to link the program, and you can modify the link-control file as needed. You can also use linkers other than the one supplied with RM/Forte.

RM/Forte lets you execute a program with or without the debug option. During debug sessions, RM/Forte lets you move between program output, the interactive debugger, and source-code editing with keystroke commands.

RM/Screens, the screen generator, works with the RM/COBOL-85 compiler, generating COBOL code. It also generates code for the validation checks that ensure that your data meets each field's criteria. RM/Screens can reduce the time you spend producing screens by up to 40 percent.

RM/Screens includes a subsystem that defines screens, letting you design or recall previously stored screens for use in the applications. You can define up to 250 fields per screen and select from a palette of 16 colors. Editing functions are available, as are features for writing and masking literals. You also have a selection of what-you-see-is-what-you-get (WYSIWYG) screen-painting functions that simplify drawing, filling, and moving boxes, and drawing line graphics. Built-in primitives, such as window-like small screens and screen shifting, also simplify and speed the design process.

Another subsystem lets you define fields, field-entry sequences, and a range of field-validation criteria. Using the field directory, you can recall any field definition, including its validation logic, and use them in other screens.

A screen generator produces error-free RM/COBOL-85 source code for your screens and validation logic, after you have formatted, tested, and edited the screens.

With additional utilities, you can test your screens before you generate and compile COBOL code. A cross-referencing capability lets you manage the use of screens throughout an application by comparing listings of all fields within a screen or listing all screens containing a particular field.
Price: RM/Screens, $400; RM/FORTRAN 2.4 with RM/Forte, $595.
Contact: Ryan-McFarland Corp., 609 Deep Valley Dr., Rolling Hills Estates, CA 90274, (213) 541-4828.
Inquiry 580.

TI Professional Goes Compatible

The CSTI Compatibility System is a full-length add-in card that adds IBM compatibility to the TI Professional and TI Portable Professional computers. Containing a video controller and floppy controller, the CSTI System makes use of the TI monitor (monochrome or RGB), keyboard, system memory, and both floppy and hard disk drives. It also supports an 8087 math coprocessor.

The CSTI System includes a disk with software driver routines for the controllers, as well as routines that translate between the IBM PC applications and the TI Professional hardware. The manufacturer claims that the system is compatible with over 95 percent of IBM PC programs. The system also supports IBM PC–compatible serial ports. The system requires MS-DOS or PC-DOS, versions 2.1 to 3.2.
Price: $595.
Contact: Compatible Systems Corp., 2111 30th St., Suite M1033, Boulder, CO 80301, (303) 444-9532.
Inquiry 581.

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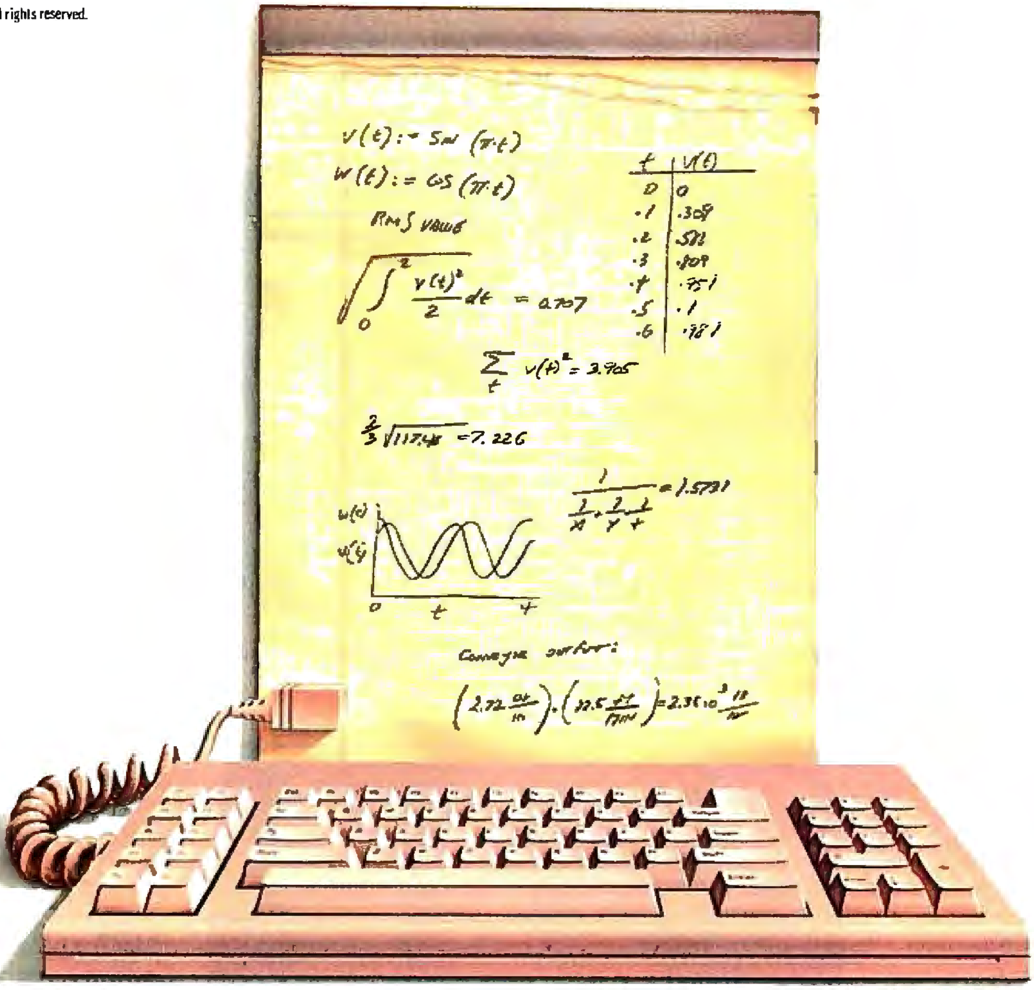


MathCAD™ turns your PC into an electronic scratchpad.

"MathCAD is a real gem of a software package... a program that breaks new ground... the starter of a new software category." The New York Times

It's the first numeric software that works like a word processor. The first software of its kind that's not a programming language. Think of it as the first WYSIWYG calculator. For the first time ever, MathCAD lets you do calculations on your PC in real math notation, as simply as on a scratchpad.

"MathCAD is likely to be a trendsetter. Its combination of mathematic power and what-you-see-is-what-you-get interface makes it an excellent tool..." PC Week

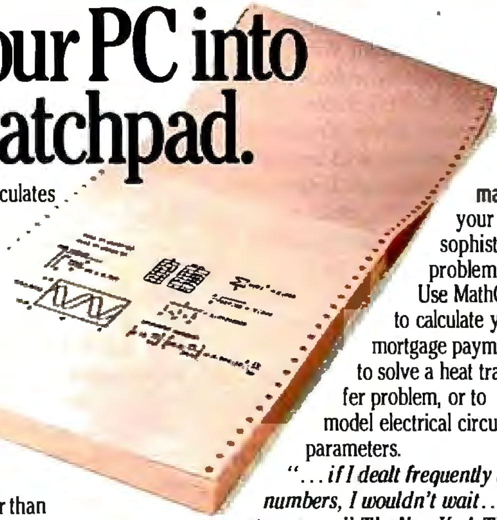
MathCAD lets you combine equations, graphics and text just like you do on paper. You can input formulas directly and edit equations interactively right on the screen. Just place the cursor anywhere and start typing. MathCAD not only formats your equations as they're typed, it instantly calculates the results. Sounds simple? It is. In fact, IEEE Software writes, "It's fun, and it's much easier to use MathCAD than anything you've ever used before."

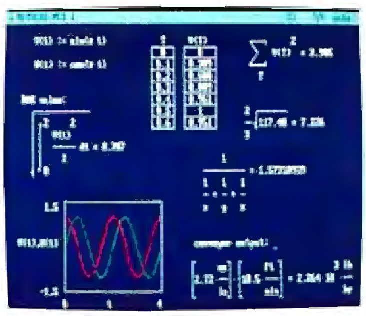
"It has a free form style that lets you just sit down in front of the PC and do the work you probably bought the computer for in the first place." PC Magazine

MathCAD is much faster and easier than doing calculations by hand or writing programs. And unlike a calculator, MathCAD lets you see and record every step. You can add text anywhere to support your work. And print or save your entire calculation as an integrated document that anyone can understand.

"It's hard to do justice to this software in any review. You feel like you've just discovered the power of a computer for the first time." IEEE Software

What kind of calculations can you do with MathCAD? Anything you have a formula for. As IEEE Software writes, "Its versatility seems unlimited." With its wide range of built-in functions, MathCAD can handle everything from simple math to your most sophisticated problems.





Use MathCAD to calculate your mortgage payments, to solve a heat transfer problem, or to model electrical circuit parameters.

"...if I dealt frequently with numbers, I wouldn't wait... to get my copy." The New York Times

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MathSoft, Inc., 1 Kendall Sq., Cambridge, MA 02139

Windows Drawing

The technical-drawing program Instinct runs in the Microsoft Windows environment and offers color capabilities and unlimited drawing size, rotation, scaling, zooming, and panning. You can merge the graphics you create with other programs to develop publications and overhead projections.

You can select and manipulate graphics, text, and menu commands with a mouse. A status window shows you what command you just invoked and what to do next.

A WYSIWYG screen display lets you create multiple drawings in separate windows and scrolls vertically or horizontally.

Layout tools include metric and English units of measurement. A built-in text editor lets you manipulate multiple lines of text and offers you a palette of text faces, sizes, and styles.

Instinct runs on the IBM PC, XT, AT, and compatibles that run Microsoft Windows. You need at least 320K bytes of RAM with two floppy disk drives. Display devices recommended include the IBM Enhanced Graphics Adapter (EGA), the Hercules Graphics Card, and other Windows-compatible devices. A copy of Microsoft Windows is also required.
Price: $99.95.
Contact: Cadlogic Systems Corp., 2635 North First St., Suite 202, San Jose, CA 95134, (408) 943-9696; in CA, (800) 962-0660.
Inquiry 582.

Graphics capabilities of Instinct used to create perspective view.

AutoCAD drawing viewed and animated with TurboView.

TurboView Speeds Up AutoCAD

TurboView converts AutoCAD drawings into high-speed assembly language format and lets you view and animate them in both orthographic and true-perspective modes. TurboView displays your drawings up to 40 times faster than AutoCAD without the math coprocessor and up to 7½ times faster than AutoCAD with the coprocessor.

TurboView also lets you manipulate up to 256 blocks in a drawing and save object-animation sequences at up to 30 frames per second.

The program works with the IBM Color Graphics Adapter (CGA), Enhanced Graphics Adapter, and SubLogic's X-1 Graphics Boards.
Price: $495.
Contact: SubLogic Corp., 713 Edgebrook Dr., Champaign, IL 61820, (217) 398-4469.
Inquiry 583.

3-Ounce Modem Gets Serial Power

Weighing three ounces and about the size of an audiocassette, the Novation Parrot is a full-featured direct-connect 300/1200-bps modem. For even greater portability, the Parrot has a microprocessor-controlled power management system that takes power directly from the RS-232C serial port. You need neither batteries nor an external AC supply. The unit only draws power from the port when needed, remaining on standby until its circuitry detects activity.

Novation claims that the Parrot is fully compatible with the Hayes AT command set. It has built-in automatic self-test, analog loop-back, and local and remote digital loop-back testing. It dials using both tone and pulse systems, it is configurable for automatic answer, and detects dial tone, busy signals, ring-back, and MCI/Sprint computer tones.

The Parrot's exact measurements are ⅜ by 4½ by 2¾ inches. It has a built-in speaker with volume control, and four LED indicators: normal, off hook, carrier, and data. RS-232C cables and communications software are optional. Starter kits are available for IBM PCs and compatibles, the Macintosh, and Commodore computers.
Price: $119.
Contact: Novation, Inc., 21345 Lassen St., Chatsworth, CA 91311, (818) 998-5060.
Inquiry 584.

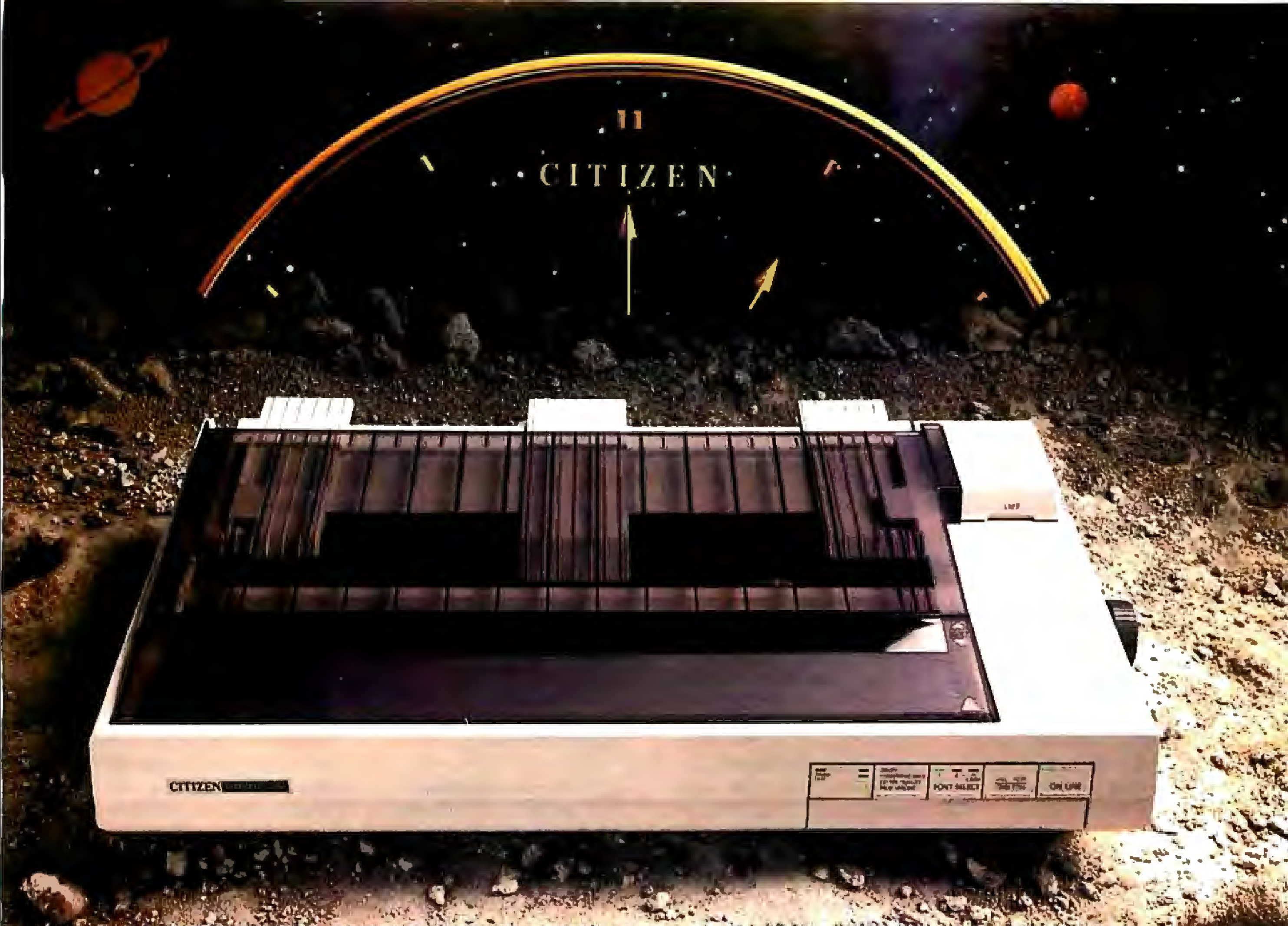
IBM/Toshiba/Zenith Laptop Expander

The CTC Expander from Cypher Technology is an expansion chassis that's designed to provide full IBM-compatible expansion capabilities for owners of the Zenith Z-171, the Toshiba T1100 or T3100, and the IBM PC Convertible.

Each CTC Expander provides four full-length and three half-length expansion slots that can be used for any IBM-compatible expansion board. There's also a slot for the custom laptop interface card, which is shipped with the chassis and connects to the laptop via a three-foot cable.

The CTC Expanders have received FCC Class B approval, and come with a 135-watt power supply.
Price: $995; with 20-megabyte hard disk, $1595.
Contact: Cypher Technology Corp., 14003 Ventura Blvd., Sherman Oaks, CA 91423, (818) 905-8161.
Inquiry 585.

continued



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The Citizen Tribute 224.
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Printers that run like clockwork.

Inquiry 52

3Com's Workstation Goes Diskless

3Station is a diskless workstation designed especially for local-area networking. Based around an 80286 processor running at 8 MHz, the 3Station's single circuit board includes monochrome, Hercules Graphics Adapter, CGA, and EGA, 1 megabyte of RAM (upgradable to 4 megabytes), and a built-in Ethernet adapter.

Because it has no expansion slots, the 3Station measures just 3 inches high and has a 14-inch-square footprint. The system draws just 25 watts of power, and does not need a cooling fan. A single parallel printer port, two serial ports, and a BNC connector for network connection are included. The 3Station comes with an IBM 101-style keyboard. A monitor is not included.

The 3Station's processor has direct access to the onboard graphics and the integrated network connection; and the system's memory mapping takes advantage of the freed-up memory area that's used for expansion slots in most IBM PC compatibles. The 3Station uses this memory area as RAM to hold the 3+ software, leaving 570K bytes of working memory available for DOS and applications.

Price: $1895.
Contact: 3Com Corp., 1365 Shorebird Way, Mountain View, CA 94043, (415) 961-9602.
Inquiry 586.

3-Com's diskless workstation.

Polaroid's Higher-Resolution Image Recorder

The PalettePlus Recorder is Polaroid's higher-end version of its Palette system for generating instant prints, slides, and overhead transparencies from computer graphics. When connected to an IBM PC-compatible system with an EGA and a graphics software package that has a PalettePlus driver, the PalettePlus can produce hardcopy with a resolution of 640 by 700 pixels. (The software without a PalettePlus Driver will produce a resolution of 640 by 350 pixels.)

When used with a CGA and software using a Palette driver, the system will produce a resolution of 640 by 400 pixels; 320 by 200 pixels without a Palette Driver.

The Recorder includes software that automatically configures the system for seven generally available EGA and CGA boards. The system includes auto-luminance circuitry, which senses and compensates for variations in the incoming video signal. There's also an electronic zoom control that fine-tunes the image plus or minus 4 percent.

Along with the exposure unit and software, the PalettePlus system includes a Polaroid 3¼- by 4¼-inch film back, an autowind 35mm camera back, a 35mm film processor, slide mounter, and cables. An optional motorized 35mm camera back is also available.

Price: $2999.
Contact: Polaroid Corp., 575 Technology Square-9P, Cambridge, MA 02139, (617) 577-2630.
Inquiry 587.

A Portable 386

As the name implies, the Noble 386 Portable is a fully portable 16-MHz 80386-based computer. Measuring 17 by 7½ by 19 inches and weighing under 35 pounds, the system is compatible with the IBM PC, XT, and AT, and comes standard with 512K bytes of RAM, which you can expand to 4 megabytes with two 2-megabyte add-on boards.

Other standard features of the Noble 386 include a 20-megabyte hard disk drive, a 360K byte floppy disk drive, and a 9-inch monochrome monitor supported by a Hercules graphics board. The system has six slots, including one for an 80387 math coprocessor. It has a Phoenix BIOS, and runs under MS-DOS or PC-DOS 3.1 and higher (not included with the basic system.)

The Noble 386 runs with one wait state, and you can toggle the clock speed from 16 MHz down to 8 MHz. The standard 20-megabyte hard disk drive has an average access time of 40 milliseconds, and a transfer speed of 5 megabits per second.

System options include a half-height 40-megabyte hard disk drive, a 1.2-megabyte floppy disk drive, and a 2-megabyte RAM board that fits into a 32-bit slot.

Price: $2999; 40-megabyte hard disk drive, $400; 1.2-megabyte floppy disk drive, $140; 2-megabyte RAM board, $700.
Contact: PC Discount, 2100 Travis, Suite 630, Houston, TX 77002, (713) 655-9047.
Inquiry 588.

AutoCAD Plotter Management

ACS Telecom's 10-Plot is plotter manager for AutoCAD that offers spool, queue, store, copy, archive, and plot capabilities. The program lets you spool drawings to a plotter or laser printer and return to AutoCAD without waiting for the plotter to finish the drawing. 10-Plot manages drawings in a single queue and plots them in order. You can archive drawing files and plot additional copies, without vector processing delays.

Spooling and queuing functions are performed from within AutoCAD, so you don't have to exit to DOS.

10-Plot requires an IBM PC, XT, AT, or compatible with MS-DOS or PC-DOS 3.0 or higher, AutoCAD 2.0, and at least 640 K bytes of RAM.

Price: $249.
Contact: ACS Telecom, 25825 Eshelman Ave., Lomita, CA 90717, (213) 325-3055.
Inquiry 589.

Stripper Tears Perfs

The Stripper is a manual tool that removes the perforated edges of computer paper and forms. To use it, you insert the perforated edge of up to 20 sheets into the unit, press down, and pull away.

Price: $14.95.
Contact: Ra-Lo Inc., East 23301 Mission, Liberty Lake, WA 99019, (800) 334-5447, (509) 928-4139.
Inquiry 590.

continued

Low-End Amiga

Commodore's new low-end member of the Amiga family is the 500. Sporting the general look of the Commodore 128, the Amiga 500 comes standard with 512K bytes of RAM, expandable to 1 megabyte internally using the optional A501 RAM expansion cartridge, which also adds a real-time clock.

With a 68000 processor running at 7.14 MHz, Commodore claims the system is fully compatible with software written for version 1.2 of Amiga 1000 systems' software. The 500 has an 18¼- by 12⅝-inch footprint, and weighs 7½ pounds. The external power supply weighs five pounds and has the system's power switch.

The new computer's keyboard has 94 keys arranged similarly to the IBM 101 layout. A single 3½-inch floppy disk drive is built in, as is an 86-pin expansion bus connector. There's also a two-button optomechanical mouse.

Price: $649.

Contact: Commodore/ Amiga, 1200 Wilson Dr., West Chester, PA 19380, (215) 431-9100.

Inquiry 591.

The $649 Amiga 500.

Zenith Z-159 Desktop Computer

The Zenith Z-159 is an enhanced, lower-priced version of the company's desktop personal computer. The Z-159 is available with either an EGA or Hercules-compatible monochrome board.

The Z-159 also accepts LMI/EMS upgrade chips, which lets you install up to 1.25 megabytes of RAM without using an expansion slot. With three additional LMI/EMS memory cards, the system will accommodate up to 5 megabytes of RAM.

With an 8088 processor switchable between 4.77 and 8 MHz, the Z-159 comes standard with 256K bytes of no-wait-state memory, serial and parallel ports, and MS-DOS version 3.2.

Price: From $1749 to $2799.

Contact: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025, (800) 842-9000.

Inquiry 592.

C.Itoh's Multiuser Micro

The CIES/286 by CIE Systems (a subsidiary of printer-maker C.Itoh) is an 80286-based multiuser system that operates at 6, 8, or 10 MHz.

The CIES/286 system is available in two-user, six-user, and nine-user configurations. The basic two-user system includes 512K bytes of RAM (expandable to 12 megabytes), a 40-megabyte hard disk drive (with average 28-millisecond track-to-track access), no-wait-state architecture, a 1.2-megabyte floppy disk drive, four open expansion slots, an RS-232C serial port, a parallel port, a 101-key keyboard, and a monochrome monitor. An EGA-compatible 14-inch color monitor is optional.

A multi-mode graphics adapter is included to support monochrome, CGA, EGA, and Hercules graphics. The system measures 9¼ by 16½ by 6¼ inches.

The system uses a Phoenix BIOS and comes with MS-DOS 3.2. Other options include a 70-megabyte hard disk drive and a cartridge tape backup unit. An optional 68000-based coprocessor board provides compatibility with PICK, RM/COS, and Unix operating systems.

Price: Two-user, $5960; six-user, $8085; nine-user, $9800.

Contact: CIE Systems Inc., 2515 McCabe Way, Irvine, CA 92714, (714) 660-1800.

Inquiry 593.

Kaypro's Complete Publishing System

Extra! Extra! is an everything-you-need desktop publishing system from Kaypro. The system hardware is based on the Kaypro 286i, an AT-compatible with 640K bytes of RAM, a 30-megabyte hard disk, an EGA color board, an EGA-compatible monochrome board, and a three-button mouse. The printer is the Kaypro Page Printer II, an eight-page-per-minute laser unit with 300 dots per inch resolution. Included are Hewlett-Packard B fonts, an assortment of downloadable fonts, and cabling needed to hook the system together.

Extra! Extra!'s software includes the Ventura desktop publishing package, WordStar 4.0 with MailMerge and CorrectStar, paint and form-generation software, MS-DOS 3.2 and GW-BASIC. Extra! Extra! can combine text from several other word processors, ASCII text, and graphics into master documents.

Price: $8495.

Contact: Kaypro Corp., 533 Stevens Ave., Solana Beach, CA 92075, (619) 481-4300.

Inquiry 594.

A Low-Cost 68000 SBC

With the HT-68K TinyGiant single-board computer, all you need to get a fully operating computer is to add a terminal, a disk drive, and a power supply. This complete 68000-based system runs at 8 MHz and has 128K bytes of no-wait-state RAM (expandable to 512K bytes on the board). Two on-board EPROMs can contain up to 64K.

The system's built-in WD1770 floppy disk controller can control up to four 5¼-inch or 3½-inch floppy disk drives. A parallel printer port and two RS-232C serial ports are also included.

Measuring 5¾ by 8 inches, the TinyGiant is not only the same size and shape as a floppy disk drive, but also has holes in the same pattern so the board can be mounted directly. The board requires the same voltage levels and uses the same type of power connectors as a 5¼-inch drive.

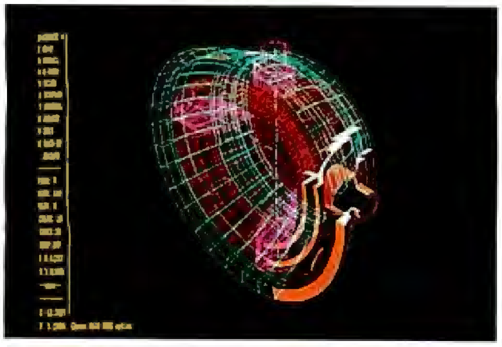
The HT-68K comes with the K-OS One single-user, single-tasking operating system that reads and writes MS-DOS-formatted disks.

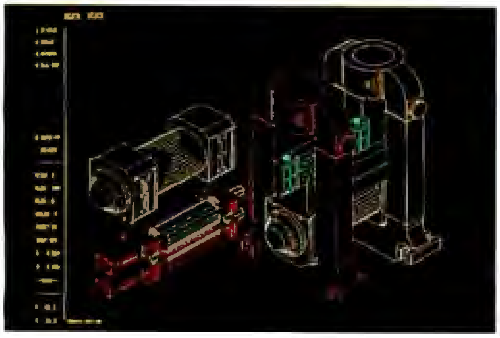
Price: $395.

Contact: Hawthorne Technology, 8836 Southeast Stark, Portland, OR 97216, (503) 254-2005.

Inquiry 595.

continued





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Inquiry 182

PERIPHERALS

Big-Screen MultiSync Monitor

Auto-Sync is a 19-inch color monitor from Microvitec that automatically locks onto any scan frequency from 15 to 36 kHz. Because specially-developed analog circuitry synchronizes both the horizontal and vertical scan frequencies, the company claims there's none of the picture-height variation found in some other multi-sync monitors.

The Auto-Sync supports graphics resolutions of up to 1024 by 580 pixels, and is available with either regular or long-persistence phosphors. It accepts both TTL and analog inputs.

Price: $2195.

Contact: Microvitec Inc., 1943 Providence Court, Airport Perimeter Business Center, College Park, GA 30337, (404) 991-2246.

Inquiry 596.

The Microvitec automatically locks onto any scan frequency.

Rascol II gives you 2000- or 4000-line slides from your PC or AT.

Ultra High-Resolution Slide Maker

The Rascol II Personal Film Recorder from Lasergraphics produces color slides with either 2000- or 4000-line resolution. The heart of the system is a full-length plug-in card that's compatible with IBM PCs and ATs. The card contains a 68000 processor and operates as a fully independent coprocessor, performing all the intensive operations of rasterizing the image into millions of color dots.

The system is compatible with virtually all graphics software available for the IBM PC and accepts graphics in either the Lasergraphics Language or the Hewlett-Packard Graphics Language (HP-GL). In the 4000-line-resolution mode, the system can produce up to 30 slides per hour; 60 in the 2000-line-resolution mode.

Price: $4995.

Contact: Lasergraphics Inc., 17671 Cowan Ave., Irvine, CA 92714, (714) 660-9497.

Inquiry 597.

Enhanced Printers: High and Low End

The P351C Model 2 from Toshiba is an enhanced version of its 3-in-1 dot-matrix printer designed to produce color text and graphics as well as 24-pin letter quality. Graphics resolution is 180 by 180 or 180 by 360 dpi in up to seven colors. It will print at 300 characters per inch in draft mode, 250 cps in the condensed printing mode, and 100 cps in near-letter-quality mode.

Toshiba has redesigned and augmented the LED front-panel display so you can select print quality, font, pitch, paper motion, or the new "quiet" mode at the touch of a button. Also, the DIP switches are now located directly behind the front panel for easy access.

The printer can handle paper sizes from 4 to 15 inches in friction-feed mode. In addition to a bottom-feed provision that handles multipart forms, other standard features are three resident type fonts (prestige elite, courier, and high-speed draft), and the ability to accept a wide variety of type fonts from optional disks or cartridges. The Model 2 can emulate the Qume Sprint 11, IBM Graphics Printer, and IBM Color Printer. Increased software support is now provided with most of the popular packages.

Optional paper-handling accessories include a dual-bin sheetfeeder, unidirectional and bidirectional tractors.

Price: $1749.

Contact: Toshiba America Inc., Information Systems Division, 2441 Michelle Dr., Tustin, CA 92680, (714) 730-5000.

Inquiry 598.

The "Plus" version is C.Itoh's enhanced ProWriter Jr. The unit prints 160 cps in draft mode, a 33 percent improvement over the original. Throughput on the Plus has been increased from 48 to 61 lines per minute, and the size of the printer buffer has been enlarged to 8K bytes.

The ProWriter Jr. Plus has a 30-cps near-letter-quality mode and a built-in printer stand that lets your paper feed from underneath the unit. Another new feature allows you to insert single sheets or envelopes into the Plus without having to remove the tractor-feed paper that's already there.

Besides fully emulating the Epson FX-80 Plus, the ProWriter Jr. Plus also has built-in IBM-compatible character sets.

Price: $369.

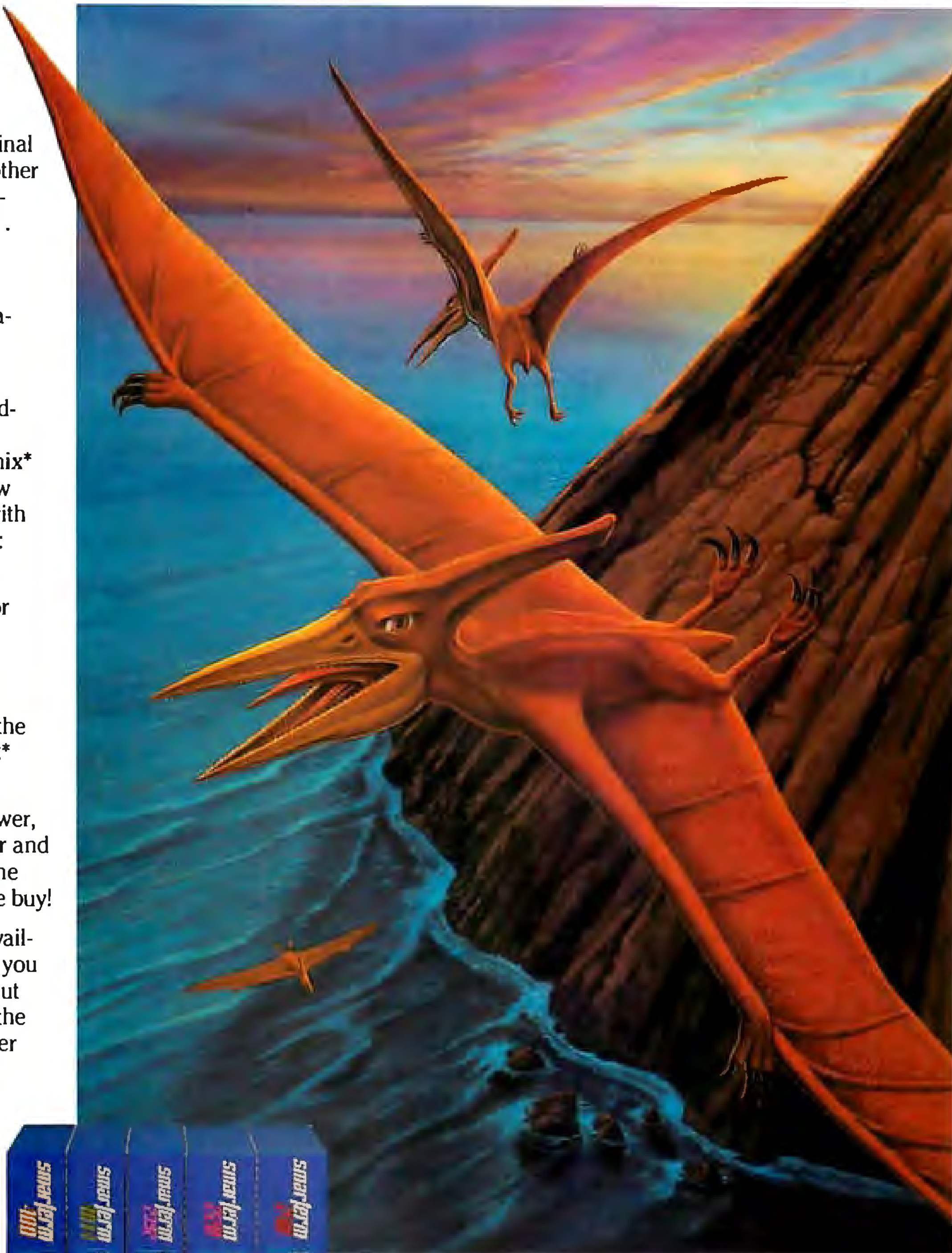
Contact: C.Itoh Digital Products Inc., 19750 South Vermont Ave., Suite 220, Torrance, CA 90502, (800) 423-0300, (213) 327-2110.

Inquiry 599.

continued

The SmarTerm® Theory of Software Evolution

What *Really* Happened to the Dinosaurs?



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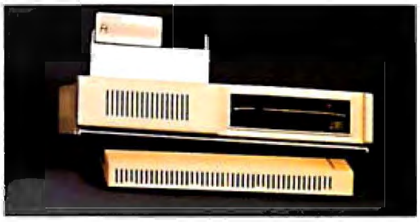

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ADD-INS

PC Building Blocks from DataBlocks

PC Link is the PC version of DataBlocks' process control/robotics system that lets you interface a virtually unlimited number of the company's Altair-II (A-II) process control blocks to a PC or compatible while using just one expansion slot.

The PC Link interface card provides complete buffering on and off the PC bus, and only loads the bus with a single CMOS load to prevent degradation. The board is designed to operate at full system speed with no wait states.

All IBM PC-compatible I/O commands are converted to A-II commands by the board. The A-II blocks consist of a wide variety of low-cost control modules, with some 37 currently available. Included are A/D and D/A converters, relay blocks, voice synthesis and recognition, a master/slave system, DC switches, timing blocks, a PROM programmer, PROM and RAM disk systems, and others.

Price: $187; blocks range from $49 to $566.
Contact: DataBlocks Inc., 579 Snowhill Rd., Glenwood, GA 30428, (800) 652-1336; in GA, (912) 568-7101.
Inquiry 600.

Data Block's system building blocks.

Jumbo Memory for 286/386 Systems

The Elite 16 memory-expansion board adds up to 16 megabytes of EMS/EEMS-compatible high-speed 16-bit memory to 80286 or 80386-based systems using a single full-length expansion slot. The board works with no wait states at 6- and 8-MHz clock speeds; with one wait state at 10 and 12 MHz.

256K-byte by 9-bit RAM modules are standard, and are directly interchangeable with 1-megabit modules. A single RS-232C serial port along with a parallel printer port are standard, and a second serial port is optional.

No switch or jumper settings are needed to install the board. Elite 16 comes with AutoRAM software that provides automatic installation by automatically determining the amount of conventional and extended memory that is already in the system, determining how much memory is installed on the Elite 16, and allocating conventional, extended, and expanded memory. You can change the default values via software, and the installation software also automatically locks out malfunctioning memory locations.

Price: $695 (with 512K).
Contact: Profit Systems Inc., 30150 Telegraph Rd., Birmingham, MI 48010, (313) 647-5010.
Inquiry 601.

HAL Controls the (Real) World

Designed as an aid to the handicapped, Home Automation Link (HAL) lets you control your computer by voice, and link voice commands to the operation of home appliances. You can use voice commands to either bypass or augment keyboard input.

The system includes the IntroVoice V voice-recognition board (a half card for IBM ATs, XTs, and compatibles), a headset microphone (Shure SM10A), and a half-length circuit board for voice control of a speaker phone and remote TV tuner (a half card). The software consists of HAL environmental software (which runs in background memory and uses 80K bytes of RAM), Multiple Choice and AutoMenu software (which runs in foreground memory for menu-driven task selection and uses 36K bytes of RAM), and voice-recognition software (which uses 64K bytes of RAM).

Options include Radio Shack's speaker phone and a Teknika remote-controlled TV tuner, among others.

The system runs on MS-DOS-based IBM PC ATs, XTs, and compatibles and requires 512K bytes of RAM and a 20-megabyte hard disk. To use the system to control lamps and appliances, you also need the optional BSR Unit.

Price: $995 for the HAL system; $149 for BSR Unit; $75 for Radio Shack's Duo-Phone; $295 for Teknika's 6510 TV tuner.
Contact: The Voice Connection, 17835 Sky Park Circle, Suite C, Irvine, CA 92714, (714) 261-2366.
Inquiry 602.

Fileserver Expansion for the Compaq 386

The 10-Disk/386 Expansion Kit from ACS Telecom increases the storage capacity and speed of the Compaq Deskpro 386. It's specifically designed to turn the Deskpro 386 into a high-powered fileserver for local area networks, and works with ACS Telecom's 10-CAD, Fox Research's 10-Net, 3Com, IBM's Token Ring Network, and ARCnet.

The 10-Disk/386 adds as much as 630 megabytes of hard disk storage to the Deskpro 386 models 40, 70, or 130. Using a 10-megabit-per-second data-transfer rate, 1:1 interleave, and low access time, the system increases Deskpro 386 throughput by more than 60 percent.

The system uses up to 8 megabytes of high-speed, 32-bit RAM to cache most disk-read requests using an intelligent, most-frequently-used algorithm. The 10-Disk/386 is completely compatible with the Compaq 386 built-in disk controller for a combined storage capacity of up to 760 megabytes.

Price: starting at $5595.
Contact: ACS Telecom, 25825 Eshelman Ave., Lomita, CA 90717, (213) 325-3055.
Inquiry 603.

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"Hello, I'm not ...[*]... Dad! I'm not here, but my computer knows exactly where I am and will pass your message on to me immediately. Wait for the tone and tell me where you are. I'll call you right back."

REALLY PERSONAL MESSAGES FOR FREQUENT CALLERS
"Hello, I'm not avai ...[*]... Tess! Sweetheart! I'm in the car, picking up your flowers. My car phone number is 993-1234 if you need me. Otherwise, see you at seven. Kiss-kiss-kiss!"

MESSAGE FORWARDING
"Hello. This is your answering machine calling...[*]... Three new messages. Message one was received at 3:52PM today."

MULTIPLE VOICE MAIL BOXES
"Hi. This is the operating systems group. We're out to lunch, but you can leave a private message by dialing 11 for Chip, 12 for Morris, 13 for Joel and 14 for Bob. Or you can wait for the tone to leave a message for our secretary."

INCREASED SECRETARIAL PRODUCTIVITY
"This is Gordie's voice mailbox. Please wait for the tone and leave a message. My computer knows where I am at all times and will call me immediately with your message. If you need to speak to someone right away, touch zero to transfer to my secretary."

DON'T FORGET MOM!
"This is Chip. Please ...[*]... Hi, Mom. I've been waiting for your call. How's Europe? Thanks for remembering my birthday. Sorry I missed you, but I had to run some errands. See you Thursday at the airport."

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QuickBASIC 3.0

Microsoft has upgraded QuickBASIC to version 3.0 with a faster compiler, improved debugging, and in-line support for the 8087 and 80287 math coprocessors. The enhanced debugger is based on the CodeView debuggers offered with the Microsoft C Compiler. It lets you begin debugging while a program is running by pressing Control-Break. You can find errors by stepping through the source code while it is executing, using animate, trace, or single-step modes. You can see the contents of variables while the program is running, and you can set, examine, and clear dynamic breakpoints to stop a program during execution. Another feature lets you divide the screen into windows and view the source code, variable contents, and program output simultaneously while the program is running.

The coprocessor support added to QuickBASIC 3.0 lets you generate faster code if you have a coprocessor, or it will automatically switch to 8087 software emulation routines that offer the same 80-bit IEEE math accuracy, according to Microsoft.

Other programming features include support for local and global variables, block If . . . Then . . . Else statements, the ability to use alphanumeric line labels instead of line numbers, and separate compilation, which lets you divide your programs into modules and compile each independently. You can keep the modules in libraries and link them into other programs without recompiling.

Microsoft has also added an error-tracking feature to the 3.0 compiler. It keeps track of all errors found during a compilation, so you don't have to correct each error and recompile. At the end of each compilation, the compiler places the cursor on the first error it found.

The QuickBASIC integrated editor supports both insert and overstrike modes and it's compatible with SuperKey, ProKey, and SideKick. QuickBASIC 3.0 offers BASIC compatibility and supports graphics statements, sound statements, and EGA extended graphics modes.

QuickBASIC 3.0 requires an IBM PC or compatible with 320K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher and supports 5¼- and 3½-inch disk formats.

Price: $99.

Contact: Microsoft Corp., P.O. Box 97017, Redmond, WA 98073-9717, (800) 426-9400; in WA or AK, (206) 882-8080.

Inquiry 604.

Turbo Pascal Source Code Debugger

Turbosmith runs as an invisible shell around Turbo Pascal and is displayed as a menu item on Turbo Pascal's main menu. Turbosmith was designed around a portion of Visual Age's symbolic debugger, CodeSmith-86.

When you start up Turbosmith, 14 lines of your source code are displayed in an upper window, and 10 lines of local variables are displayed in a lower window. The next statement to execute is highlighted.

The program features four interactive window types that you can select for various views of your Turbo Pascal code. A Variable View window lets you view or change variables at the time the source code statements are being executed. The multiwindow displays are based on a worksheet-type visual interface.

A single keystroke can switch you from one window to another, if the variables you need are in a nested calling procedure rather than the procedure you're tracing. The variable your cursor is on is highlighted, and you can overstrike variables, if necessary.

You can stack windows up to eight deep. Some of the windows include a machine-language disassembler window, synchronized source- and machine-code windows, and a Hex/ASCII memory-dump window.

Turbosmith also lets you create and debug on the same monitor and features dual-monitor debugging. A Screen Save mode prevents you from destroying your program when you create and debug on the same monitor.

The program is written in assembly language and runs on IBM PCs, XTs, ATs, and compatibles with MS-DOS or PC-DOS. Visual Age recommends 512K bytes of RAM to run Turbosmith and Turbo Pascal. A copy of Turbo Pascal 3.0 or higher is also required.

Price: $69.

Contact: Visual Age, 642 North Larchmont Blvd., Los Angeles, CA 90004, (800) 732-2345; in CA, (213) 534-4202.

Inquiry 605.

Pascal Helper

Pascal Helper from Modular Software assists you in designing and creating programs with Turbo, IBM, or Microsoft Pascal. You write the Pascal module, and Pascal Helper does the rest.

In creating screens, the program defines your variables and develops the main program and the language-dependent low-level procedures. The main program, the Runtime.Mod, and your calculation procedure, complete the program.

The Runtime.Mod source-code module, consisting of 121 procedures logically grouped into modules, is included with Pascal Helper. You can remove or replace some of the modules to modify your applications.

It also includes an editor with character, line, and block commands along with commands for duplicating lines and drawing lines, boxes, and logos. The editor also has three help screens.

To run Pascal Helper you need an IBM PC, XT, PCjr, AT, or compatible with at least 128K bytes of RAM. A floppy or a hard disk drive is required along with MS-DOS or PC-DOS 2.0 or higher. You also need a composite, monochrome, or color display and a Turbo, IBM, or Microsoft Pascal compiler to compile and run your applications. To use the color capabilities of Pascal Helper, you must have a color adapter. The program is not copy-protected.

Price: $79.95.

Contact: Modular Software Inc., 329 Hope St., Stamford, CT 60906, (800) 227-1032; in CT, (203) 854-8806.

Inquiry 606.

Edit with ME

Magma Software's text editor, ME, features a macro language that lets you create new editor commands and configure your programming environment. Other features include multiple windows, regular expressions, line marking, column mode, and one-keystroke macros.

ME runs on IBM PCs and compatibles and supports the Enhanced Graphics Adapter.

Price: $35 for the editor; $85 for editor and source code.

Contact: Magma Software Systems, 138-23 Hoover Ave., Jamaica, NY 11435, (718) 793-5670.

Inquiry 607.

continued

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Inquiry 167 for End-Users. Inquiry 168 for DEALERS ONLY.

Printed Circuit Board Design on the Macintosh

Douglas CAD/CAM lets you create layouts of printed circuit boards on the Apple Macintosh. During layout, the software creates a database used in the board manufacturing process.

The software accommodates a variety of grids, pads, holes, and trace widths, and provides a layout area of 32 by 32 inches. All parts are user-definable. Input is by a mouse and you can output to printers and pen plotters, or you can output the system's Gerber-formatted data to tape drives for photoplotting.
Price: $95; $395 with drivers for the Apple ImageWriter and LaserWriter printers; $525 with drivers for the printers and various pen plotters.
Contact: Douglas Electronics Inc., 718 Marina Blvd., San Leandro, CA 94577, (415) 483-8770.
Inquiry 608.

Circuit layout created with Douglas CAD/CAM.

Active Filter Design

The Active Filter Design program is a menu-driven utility that helps you synthesize active filter circuits. An error-checking feature prevents you from entering incompatible data. Screen windows show the currently activated portion of the program as well as the nesting level of the current menu.

Preformatted filter parameters are included, and you can also create your own parameters and store them on disk.

Lars Olsson Engineering says that it takes about 10 minutes to design moderately complex filters of any class.

The program runs on the IBM PC, XT, AT, and compatibles with at least 128K bytes of RAM and an IBM Color Graphics Adapter. You can plot on IBM graphics-compatible printers.
Price: $799.
Contact: Lars Olsson Engineering, 561 Pine St., Edmonds, WA 98020, (206) 778-9480.
Inquiry 609.

Scientific Subroutines

Mathpac from Systolic Systems is a scientific subroutine program optimized for IBM PC XTs and ATs equipped with 8087 math coprocessors. The program is available in Microsoft FORTRAN, IBM Professional FORTRAN, Ryan-McFarland FORTRAN, Microsoft C, Lattice C, and Computer Innovations C86.

The program has a library of over 400 FORTRAN math routines, which you can link with your own application code. It includes matrix/vector routines, linear equation solvers, numerical integration methods, simulation tools, optimization algorithms, and eigenvalue analyses. It also contains a signal-processing library for fast Fourier transforms, digital filtering, correlation, convolution, and spectrum analysis. Other libraries include real- and complex-vector operations, real- and complex-matrix operations, image processing, simulation and integration methods, numerical optimization, control system analysis and design, and a computer graphics library.

You can display the data on monochrome and color displays with up to 16 variables plotted on the same graph. You can graph X and Y plots, log-log plots, and bar and pie charts.
Price: $495.
Contact: Systolic Systems Inc., 2440 North First St., San Jose, CA 95131-2310, (408) 435-1760.
Inquiry 610.

Finite-Element Analysis Added to CAD

ADCAD2 version 2.0 lets you link programs with MSC/Pal 2 for finite-element analysis, and then transfer the results back to the CAD program. MacNeal-Schwendler says that any CAD program that uses DXF file-transfer can use ADCAD2 2.0.

To use ADCAD2, you must mesh the structure by breaking it into beams, triangles, and quadrilaterals from within the CAD program. Then you answer a series of questions about the drawing, including its filename, the file format, and the type of material used in the design (only one type of material can be used in each drawing). ADCAD2 then translates the drawing into MSC/Pal 2 format, where it is analyzed and MSC/Pal 2 creates a version of the drawing that exposes the drawing's structural weaknesses. Then ADCAD2 transfers the altered drawing back to the CAD program (as a DXF file) and displays it as an overlay on the original.

You need an IBM PC or compatible with MS-DOS or PC-DOS 2.1 or higher, 512K bytes of RAM, an IBM Color Graphics Adapter or compatible graphics display, and a math coprocessor. You can print the MSC/Pal 2 drawings on plotters supported by the CAD program.
Price: $95.
Contact: MacNeal-Schwendler Corp., 815 Colorado Blvd., Los Angeles, CA 90041, (213) 259-3875.
Inquiry 611.

continued

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PC MAGAZINE "EDITORS CHOICE"

"...To sum up my feelings about this mouse and menu generating system: this is the one I want." Phil Wiswell
PC Magazine, Jan 27, 1987

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The smooth-tracking LOGITECH mouse is a productivity tool for all types of data entry and editing. We've even created a special mouse interface for 1-2-3 which makes 1-2-3 users up to 30% more productive!

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"Logitech's Plus Package adds an excellent menu builder (with useful examples), a fast windowing text editor, and an outstanding Lotus 1-2-3 interface." Ezra Shapiro
Byte, Dec. '86, pg. 324

Our Plus Software also includes our Microsoft-compatible drivers, and CLICK which sets the mouse automatically for any application.

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SOFTWARE • BUSINESS AND OTHER

Information Tracking

DayFlo's Tracker is a database with word-processing features that lets you keep track of everything. You can enter data using the standard forms that come with the system or develop your own by following a menu-directed procedure that requires no programming. You can enter up to 65,000 records per database and print using any of the system's 45 standard reports.

An Application Pack is offered as an option, and it provides ready-to-use application templates for contact records, article-abstract records, task records, and DOS file records.

When entering information into Tracker's records, the length of each field grows to accommodate your text. You can incorporate keywords into each record, so that later on you can recall all the information relating to a particular keyword. After retrieving information, you can use the report-writing capability to produce reports that contain text and tables. You can output to a printer, display, or to DOS files. Other features include text and number formatting with calculations including derived columns, totals, averages, counts, and subcalcs. DayFlo reports that calculations are accurate to 15 digits. A menu-driven mass-mailing capability is also offered, and you can use preprinted forms. You also have the ability to import files from other word-processing programs.

To run Tracker, you need an IBM PC AT, XT, or compatible with MS-DOS or PC-DOS 2.0 or higher, at least 1 megabyte of hard disk space, 384K bytes of RAM, and a monochrome, CGA, or EGA monitor. A graphics adapter is not required.
Price: $149.95; Application Pack, $39.95.
Contact: DayFlo Software, 17701 Mitchell Ave. N, Irvine, CA 92714, (714) 474-1364.
Inquiry 612.

re:Source from The Source.

re:Source

The communications program re:Source is an interface between your IBM PC and on-line services like The Source. You can automate frequent command sequences, integrate database information, and customize your own on-line scripts before you get on line.

The price of the program includes membership in The Source's information network.
Price: $89.
Contact: The Source, 1616 Anderson Rd., McLean, VA 22102, (703) 734-7500.
Inquiry 613.

Harvard Graphics

Harvard Graphics, a new version of Harvard Presentation Graphics, offers new chart types and options, built-in drawing capability, production tools, and a desktop slide-show feature.

New graph types include histograms, logarithmic charts, paired bars, dual *y*-axis graphs, and proportional pie charts. Mathematical and statistical calculations include 19 keyword formulas such as sum, average, moving average, and regression. Harvard Graphics offers you three-dimensional options for producing bar, line, and area charts, and you have the ability to place multiple charts on a page, 240 data points per graph, and 60 characters per line in text charts. A user-definable palette of 16 colors is also available.

Drawing tools such as circles, ellipses, polygons, and polylines offer fill, outline color, and outline pattern options. You can group and ungroup drawings for moving and resizing. Preformatted charts are available, or you can create your own. Templates let you select chart attributes once and reuse your selection. You can group charts into chartbooks, and an Automatic DataLink lets you link a Lotus 1-2-3 worksheet to a chart template, loading the data automatically when you retrieve a template.

The Screenshow feature lets you create slide presentations at your desktop. You can control the motion by moving backward, forward, pausing, and restarting slides.

Harvard Graphics runs on IBM PCs with at least 512K bytes of RAM. You can use most output devices and most high-resolution video boards, according to Software Publishing.
Price: $395.
Contact: Software Publishing Corp., P.O. Box 7210, Mountain View, CA 94039-7210, (415) 962-8910.
Inquiry 614.

Music Construction Set for the Apple IIGS

Music Construction Set is now available for the Apple IIGS. The music program features 15 digitized instruments and supports musical instrument digital interface ouput to MIDI-compatible keyboards and instruments as well as to the SuperSonic stereo card from MDIdeas Inc.

Music Construction Set takes advantage of the mouse and windows interface of the IIGS. High-resolution graphics is used on-screen, and the program can print in standard sheet-music format. Other features include cut-and-paste editing and a library of musical notation items, including thirty-second notes, rests, slurs, quintuplets, double sharps and flats, and octave raisers.
Price: $49.
Contact: Electronic Arts, 1820 Gateway Dr., San Mateo, CA 94404, (415) 571-7171.
Inquiry 615.

SEND US YOUR NEW PRODUCT RELEASE

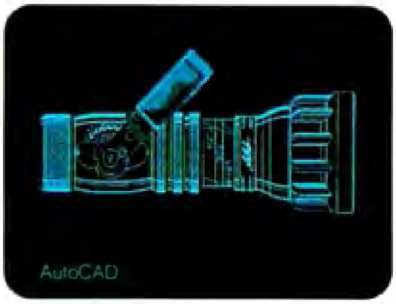
If you want us to consider your product for publication, send us full information about it, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified.

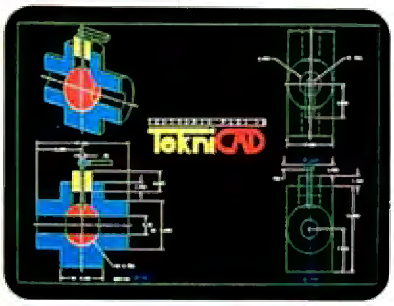

TEKTRONIX NEW
ADVANCED PC GRAPHICS
STANDS ALONE.
AERODYNAMIC HEATING
EQUILIBRIUM TEMPERATURE
CONE SECTION
CYLINDRICAL SECTION
TEMPERATURE
DISTANCE
TIME

BECAUSE IT WORKS TOGETHER.

Introducing Tek Advanced PC Graphics: a fully integrated system of high-performance graphics, easy system connectivity, and unparalleled application software for your PC. Tek Advanced PC Graphics starts with a flexible multiple-rate color graphics monitor that provides 640x480 Tektronix-style graphics as well as EGA and CGA software compatibility.

Driving your monitor to a whole new level of graphics speed is Tek's PC4100 graphics coprocessor board. It features Texas Instruments* powerful TMS 34010 32-bit



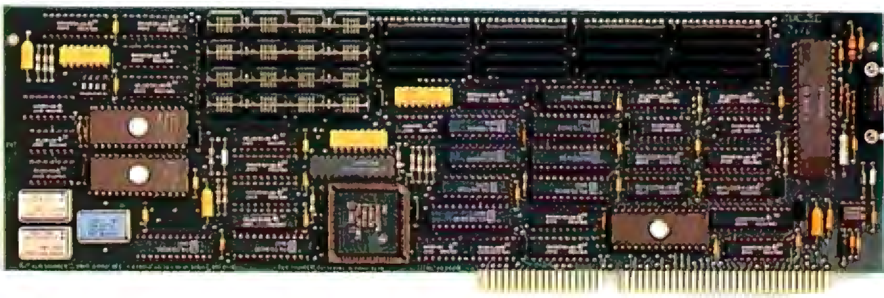


Graphics System Processor for ultra-fast throughput of your design applications. Add to that Tek's PC-05 or PC-07 terminal emulation software, and you're ready for stand-alone computing or access to a world of mainframe graphics.

To bring those applications to life, you can connect a Tek color ink-jet printer. And start producing high-resolution, vibrant hardcopy output on either paper or transparencies.

Couple all that with Tektronix worldwide support and service, and your PC can gain the same productive advantages that host-based systems in scientific and engineering environments have had for close to two decades.

Tek's PC4100 graphics coprocessor board delivers serious graphics on a stand-alone basis. Built around the Texas Instruments Graphics System Processor(GSP),™ the graphics coprocessor board achieves a combination of sophisticated graphics and fast throughput your PC just couldn't deliver before. The GSP assumes the complete graphics processing workload, freeing your PC processor for other requirements.



New companion monitor brings together fine detail and maximum flexibility. You'll view your applications on Tek's new multiple-rate monitor. In true Tek tradition, it provides ideally balanced, 640x480 addressability and a 60 Hz non-interlaced refresh rate. So you can use advanced packages like AutoCAD,® Zenographic's Mirage™ and VersaCAD.®

Then, to move from GSP graphics to emulation of the IBM® Enhanced Graphics Adapter(EGA) mode, you simply soft-switch. And you're ready to run the popular PC packages you probably already use in CGA/EGA mode—standards like Lotus® 1-2-3,® Microsoft® WORD® and Microsoft® Windows,® to name just a few.

Last, but not least, Tek's PC4100 links you to a world of mainframe graphics. All you do is load Tek PC-05/PC-07.

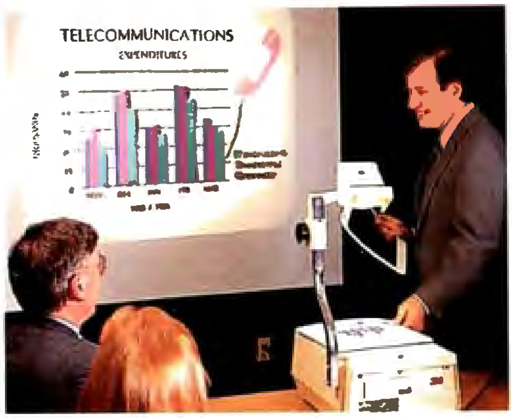
Tek PC-05/PC-07 terminal emulation software gives you mainframe accessibility with the local processing power of your PC. Because Tek PC-05 and PC-07 terminal emulation software runs under MS-DOS® 2.0 and higher, you can run your mainframe-based

AND SETS YOU APART.

applications software on your PC as if it were a Tek 4105 or 4107 terminal.

Which means you can quickly access the power of Tek graphics—including 4107 segments, true zoom and pan, rubber-banding, definition of up to 64 viewports and more. You can use these highly productive features with a wide range of well-known designer software packages such as ISSCO's DISSPLA® and TELL-A-GRAF,® MCS's ANVIL-5000,™ SAS Institute Inc.'s SAS/GRAPH, Precision Visuals' DI-3000,® Swanson Analysis Systems' ANSYS® and McNeal-Schwendler's NASTRAN.

In addition, you can utilize software development tool sets like Tektronix PLOT 10® GKS, IGL, TCS and STI software as well as numerous driver support packages created for the 4105 and 4107.



Completing the picture: perfect color output with Tek's reliable ink-jet printers. At the push of a button, the Tek 4696 lets you produce exacting color reproductions of your on-screen display on either paper or transparencies.

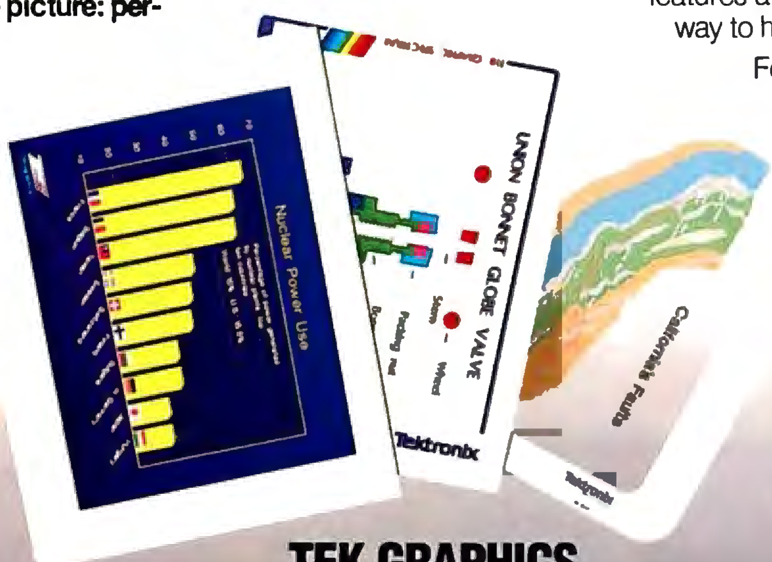
Because of its 120 dots per inch addressability in both horizontal and vertical directions, you can achieve resolution of up to 1280 points x 960 points per "A" size image.

All the key tools for software development, right from the outset. The new Tektronix Graphics Interface™ (TGI) for the PC provides the basics of Tek graphics functionality to application programs running under MS-DOS. What's more, in-circuit emulator, C-compiler, assembler and linker are all available from Texas Instruments to help software developers write applications packages for the PC4100 graphics coprocessor board.

To enable sufficient workspace for custom interfaces or specific application programs, the PC4100 graphics coprocessor board comes standard with a full megabyte of program memory.

Put yourself on the sure path of Tek graphics evolution. Whether you choose Tek PC stand-alone graphics, Tek's high-resolution monitor, Tek terminal emulation or all three, you can be assured Tek will keep you current with the best and most productive graphics. Because like all our products, Tek Advanced PC Graphics features a smooth built-in pathway to higher-level graphics.

For more information about how Tek lets you stand alone and work together, contact your local Tek representative about Tek Advanced PC Graphics. Or call, 1-800-225-5434. In Oregon, 1-235-7202.



TEK GRAPHICS PROCESSING SYSTEMS

Tektronix
COMMITTED TO EXCELLENCE

VPT 102 11W-7050

EVENTS AND CLUBS

June 1987

EVENTS

COMDEX/Spring, Atlanta, GA. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. *June 1–4*

Real-Time Factory Control, Detroit, MI. Dianne Leverton, Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-1500, extension 383. *June 2–4*

Third International Expert Systems Conference and Exhibition, London, England. Learned Information Ltd., Woodside, Hinksey Hill, Oxford OXI 5AU, England, 0865-730275. *June 2–4*

Troubleshooting Microprocessor-based Equipment and Digital Devices, Dallas, TX, and other locations in the U.S. Janet McHenry, Micro Systems Institute, Garnett, KS 66032, (913) 898-4695. *June 2–4*

Artificial Intelligence and Advanced Computer Technology Conference and Exhibition/Europa, Frankfurt, West Germany. TCM Expositions Ltd., 331 West Wesley St., Wheaton, IL 60187, (312) 668-8100. *June 3–5*

ROBEXS '87, Pittsburgh, PA. Instrument Society of America, 67 Alexander Dr., P.O. Box 12277, Research Triangle Park, NC 27709, (919) 549-8411. *June 4–5*

Sixteenth Annual Meeting of the MUMPS Users' Group, Atlanta, GA. MUMPS Users' Group, 4321 Hartwick Rd., Suite 510, College Park, MD 20740, (301) 779-6555. *June 8–12*

USENIX Summer Conference and Exhibition, Phoenix, AZ. USENIX Conference Office, P.O. Box 385, Sunset Beach, CA 90742, (213) 592-1381. *June 8–12*

Computex Taipei '87, Taiwan, R.O.C. Taipei World Trade Center, 201 Tunhwa North Rd., Taipei 10591, Taiwan, Republic of China, (02) 715-1515. *June 8–14*

ESD/SMI Expert Systems for Advanced Manufacturing Technology Conference and Exposition, Dearborn, MI. Marion L. Weber, Conference Administrator, Engineering Society of Detroit, 100 Farnsworth, Detroit, MI 48202, (313) 832-5400. *June 9–11*

Thirty-fifth Annual Technical Writers' Institute, Troy, NY. Office of Continuing Studies, Rensselaer Polytechnic Institute, Troy, NY 12180, (518) 266-6442. *June 9–12*

Advanced Printed Circuit Board Design Techniques, Milwaukee, WI. Peter L. Tocups, Program Director, Center for Continuing Engineering Education, University of Wisconsin–Milwaukee, 929 North Sixth St., Milwaukee, WI 53203, (414) 227-3125. *June 10–12*

National Computer Conference, Chicago, IL. NCC '87, American Federation of Information Processing Societies, 1899 Preston White Dr., Reston, VA 22091, (800) 622-1987; in Virginia, (703) 620-8955. *June 15–18*

ISDN/Broadband Networks for the Future, Atlanta, GA. Information Gatekeepers Inc., 214 Harvard Ave., Boston, MA 02134, (617) 232-3111. *June 15–19*

COMDEX International in Europe, Nice, France. The Interface Group, 300 First Ave., Needham, MA 02194, (617) 449-6600. *June 16–18*

IEEE First Annual International Conference on Neural Networks, San Diego, CA. Nomi Feldman, Conference Coordinator, 3770 Tansy St., San Diego, CA 92121, (619) 453-6222. *June 21–24*

1987 National Educational Computing Conference, Philadelphia, PA. Gayle J. Yaverbaum, Temple University, Department of Computer and Information Science, Computer Activities Building, Philadelphia, PA 19122, (215) 787-8810. *June 24–26*

VDT Health & Safety, Washington, DC. Continuing Education Institute, 21250 Califa St., Suite 102, Woodland Hills, CA 91367, (818) 710-1126. *June 25–26*

If you send notice of your organization's public activities at least four months in advance, we will publish them as space permits. Please send them to BYTE (Events and Clubs), One Phoenix Mill Lane, Peterborough, NH 03458.

CLUBS

New York Personal Computer Inc., Suite 614, 80 Wall St., New York, NY 10005, (212) 533-6972.

C Users Group Italia, c/o Fabrizio Virtuani, Via Valsesia 86, 20152 Milano, Italy.

International Computing Association (ICA), c/o Markus H. Maege, Roebbek 6, 2000 Hamburg 52, West Germany, (49) 40-632-3517.

WorldWide Commodore, P.O. Box 4002, S-35004 Vaxjo, Sweden.

The Carrier, newsletter of the Telecommunications Users Group; P.O. Box 45254, Seattle, WA 98145.

Columbia-Baltimore User Group (CBUG), P.O. Box 125, Columbia, MD 21045, BBS: (301) 730-5624.

Real Times, Greater Boston Chapter newsletter of The Association for Computing Machinery; P.O. Box 465, Lexington, MA 02173.

South Bay Apricot Users Group, c/o Ken Stevens, 17302 Yukon Ave., Suite 11, Torrance, CA 90504, (213) 515-7718.

Connect, newsletter of the South Jersey ST Users Group; 205 Emerald Ave., Westmont, NJ 08108, BBS: (609) 858-7817.

Tandem Users' Journal, the International Tandem Users' Group (ITUG); 111 East Wacker Dr., Suite 600, Chicago, IL 60601, (312) 644-6610.

MacHonor Bulletin, newsletter for CE Software Customers; CE Software, 801 73rd St., Des Moines, IA 5C312, (515) 224-1995.

Island Reach Computer Users Group, P.O. Box 73, Deer Isle, ME 04627, (207) 348-9917.

Sales Professionals Using Computers (SPUC), 218 Huntington Rd., Bridgeport, CT 06608, (203) 333-6436.

Lake County Amiga Users Group, c/o Philip Brauer, 280 Glen St., #2D, Grayslake, IL 60030, (312) 223-3209. ■

Introducing the Hercules InColor Card.

It runs more software at a higher resolution than any other color graphics card.

The Hercules® InColor™ Card offers everything you'd expect from a high resolution color graphics card from Hercules — and more.

Compatibility: The InColor Card is compatible with the thousands of programs that run on our monochrome cards.

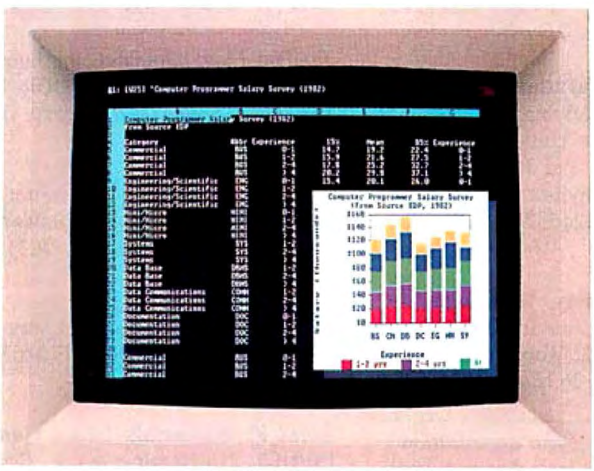
Color: The InColor Card gives color capability to Hercules-compatible software like 1-2-3® and AutoCAD®.

Resolution: The InColor Card's resolution of 720x348 is the highest of any widely supported standard.

RamFont: The InColor Card has our unique RamFont mode — in color.

Better graphics.

Hercules is known for bringing high resolution monochrome text and graphics to programs like 1-2-3® and AutoCAD®.



The InColor Card's RamFont mode gives Lotus 1-2-3 a pop-up graphics window and lets you view nearly twice as much spreadsheet data—all in full color.

Now the InColor Card gives you the same high resolution 720x348 graphics in up to 16 colors using an IBM® Enhanced Color Display, multi-sync monitor, or equivalent.

That's the highest resolution of any widely supported graphics standard.

And no other color graphics card allows you to move back and forth between color and monochrome systems *without changing drivers.*

Runs more software.

All Hercules-compatible text, graphics and RamFont software runs on the InColor Card in black and white, or at least two colors.

And many popular programs like 1-2-3, Symphony,® AutoCAD and Microsoft® Windows that use graphics or RamFont, run in full color.

More powerful RamFont.

RamFont is a new mode developed by Hercules that gives your software the ability to display multiple fonts at lightning fast speeds.

RamFont transforms advanced word processors like Microsoft Word from slow to text-mode fast.

Technical word processors like Lotus Manuscript™ use RamFont to display onscreen the text you want to print.

Even 1-2-3 uses RamFont to almost double the size of the spreadsheet picture.

And now, with the InColor Card, you get an enhanced RamFont with 3,072 programmable characters in up to 16 colors.

All the way up to 12,288 characters in four colors.

With the InColor Card's RamFont, no program should run out of speed, color or fonts ever again.

AutoCAD gets the same high resolution 720x348 graphics as our famous monochrome cards—only now in full color on an IBM Enhanced Color Display.

What the InColor Card could mean to your company.

The InColor Card allows you to run a program in color, and then move to a Hercules Graphics Card Plus and run the same program in monochrome.

Without changing drivers.

Compatibility between the InColor Card and our monochrome card allows you to network around one standard—Hercules. At last your PCs will have compatible graphics, in color or monochrome.

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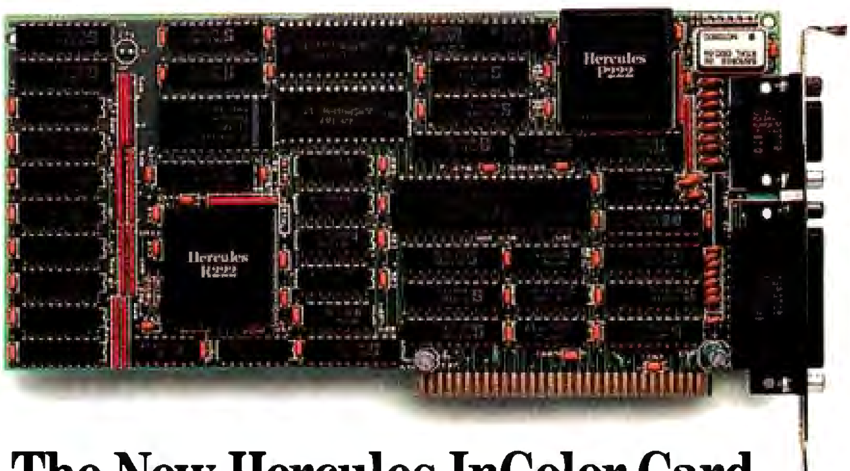
To find out more about the new Hercules InColor Card, call 1-800-532-0600 Ext. 502. (In Canada, call 1-800-323-0601 Ext. 502.)

Features of the Hercules InColor Card

- Hi-res text with 9x14 character size in up to 16 colors with attributes
- 720x348 Hercules graphics in 16 colors selected from 64 color palette
- Special RamFont mode displays 3,072 programmable characters in 16 colors with attributes, up to 12,288 characters in 4 colors
- Runs Hercules-compatible graphics software in b&w or any two background colors
- Designed for use with the IBM Enhanced Color Display, multisync monitors, or equivalents
- Software diskette includes font editor, sample fonts, and Hercules utilities
- Parallel printer port
- Two year warranty



The New Hercules InColor Card.

Hercules Computer Technology, 2550 Ninth St., Berkeley, CA 94710 Ph: 415 540-6000 Telex: 754063 Fax: 415 540-6621 Trademarks/Owner: Hercules, InColor, RamFont/Hercules; Lotus, 1-2-3, Symphony, Manuscript/Lotus; Microsoft/Microsoft; AutoCAD/AutoDesk; IBM/IBM

ASK BYTE

Conducted by Steve Ciarcia

Terminal Problems

Dear Steve:

I am having great difficulties with my computer system. I have an IBM PC AT with two serial ports and three parallel ports. I have been trying to connect a Kimtron KT-7/PC terminal (with AT-type keyboard layout) into one of the serial ports to use as an auxiliary terminal. I have used the MODE command to initialize the port and the CTTY command to change the terminal. But the only thing I can do from the Kimtron is to switch from directory to directory and call up a directory listing. When I attempt to run a program (i.e., SuperCalc3, WordStar, dBASE III, and BASICA), the terminal freezes. In some cases, the program can be seen through the main monitor.

Is this problem associated with the operating system I am using (PC-DOS 3.1), or is it the application software? I have been told that terminal set-up programs may be required; if this is the case, where can I get them?

David Ware
Oklahoma City, OK

The reason that the programs don't work on the remote terminal has nothing to do with either DOS or the rumored set-up programs. It's in the application programs, and it's not fixable. Period.

The CTTY *program simply redirects DOS's input and output requests to the remote terminal. Any program that uses DOS calls to read the keyboard and display characters on the screen will work correctly from the remote terminal. But most programs use the BIOS calls to read the keyboard, because DOS doesn't give enough information about the special keys.* CTTY *doesn't affect the BIOS calls, so programs using those calls will continue to look for characters from the PC keyboard regardless of what you type on the terminal. And some programs use both DOS and BIOS calls, so they tend not to work at all.*

Nearly all programs write directly to the screen buffers in RAM rather than using the DOS or BIOS calls, simply because that's the only way to get acceptable performance. CTTY *doesn't have any effect on memory writes, so these programs blithely sprinkle their characters on the PC's screen.*

To make matters worse, various versions of CTTY *have a variety of bugs. Because nobody ever uses it, the bugs are pretty awful. Because the bugs are pretty awful, nobody ever uses it. And so it goes.*

You'll note that most of the programs you list say that they're intended for "IBM PCs or 100 percent compatibles" (although you may have to read the fine print to find that statement). As there is no standard for remote terminals on a PC, even though CTTY *is "standard" DOS, it's not going to help you win an argument with the vendors. Sorry, but I don't have a magic fix up my sleeve for you.* —Steve

LISP Machines

Dear Steve:

I am a student of mathematics and information science at Warsaw University. I am interested in a computer for implementing some artificial intelligence systems that I have written in LISP (Common LISP version). I read about LISP machines in BYTE last year, and I wonder if you could give me some more information about them; specifically, whether they work by compiling or interpreting, and how their speed of execution compares with IBM PC XT LISP (Waltz-LISP).

Adam Kraure
Warsaw, Poland

A LISP machine is a computer that is specifically designed to run LISP programs. The memory includes (in addition to the normal data) extra bits in every memory word, to describe the data types; the CPU includes special operations to speed up LISP programs; and the display has very high resolution. As you might expect, LISP machines are not cheap: Prices start at around $20,000 for a stripped version, and beyond that the sky is the limit.

It seems that Common LISP is the emerging standard for the LISP language, so a dialect of that is probably your best bet. Newer versions are optimized for the IBM PC AT, so the performance is at least acceptable, if not in the same league as a true LISP machine. The LISP programs run using the 80286's protected mode to access up to 16 megabytes of RAM and require a great deal of disk space. You won't be able to get by with a stripped PC AT.

You might want to talk your library into a subscription to the Institute of Electrical and Electronic Engineers (IEEE) Expert *magazine. It covers the latest technical developments in the AI field and may give you some ideas on the subject. Write to the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ, 08854, U.S.A., for the subscription details. It will cost about $40 including shipping.*

Incidentally, LISP Machine is also the trade name of a company in Andover, Massachusetts. —Steve

What a Deal

Dear Steve:

If you appreciate the occasional off-the-wall question, I have a pair of them for you.

First, a few months ago, while in the U.S., I bought an Oberon Omni-Reader from California Digital. It is a rather nice optical character reader that, since Oberon had gone under, was selling for $180 rather than the original $700. The ad implied that the unit came with support for several different computers. Since I had heard of the unit and had even kept the original reviews from the U.K. press, I jumped at the chance and called in an order. As luck would have it, the unit was not delivered until after I left the U.S., so I didn't have a chance to look at it until it arrived here in Saudi Arabia.

continued

IN ASK BYTE, Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to

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

Due to the high volume of inquiries, we cannot guarantee a personal reply, but Steve and the Ask BYTE staff answer as many as time permits. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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

The software was for an IBM and the main instruction manual was missing, although it did have an interface manual with it. I hooked it up and it works. Have you ever heard of this machine or do you know anyone who might have? I am looking for any available information.

The second question relates to the first: The interface manual says that to interface the optical character reader with Apple II computers you should use the Super Serial Card as an RS-232C interface. Well, I have the old Apple serial card (which is far from super but is at least here and paid for). I wrote a short program to read from the Omni reader using INPUT statements. This program actually works but is clumsy to use. I tried using the GET statement but all I get is trash; I suspect this is a result of not being in sync with the input. I seem to recall that you designed a serial interface card for the Apple, but I only have about three years of back issues and I can't find the article. If you did, can you tell me what issue? Also, I would appreciate any suggestions you might have for my using the reader with my current setup.

Marshall P. Brown
Saudi Arabia

The original developer of the Omni-Reader, Oberon, is indeed no longer among the living. Marketing rights to the design are now owned by G.A.S International Inc., P.O. Box 1282, Euless, TX 76040, (800) 523-4898. They may be able to assist you.

Several descriptions of the Oberon character reader have been published in the American microcomputer press. The reports have indicated that, while the hardware seems capable enough, speed is limited, only a few type fonts can be read, and the error rate is unacceptably high. Software improvements by G.A.S. International may change the situation, however.

Garbage can result when the two systems disagree as to the data rate (baud) and format (number of data bits and stop bits, and the type of parity used). You might try experimenting with variations to the serial card, although your experience using INPUT *suggests that this is not the cause of your problems.*

Several commercial utility packages have been marketed that use the Applesoft ampersand vector to create routines in machine code that can be used to "input anything," from peripheral devices as well as from the keyboard. Assembly listings and descriptions of programs with similar capabilities have appeared in several of the Apple-specific computer magazines: Nibble *and* Call-A.P.P.L.E., *to*

continued

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CIARCIA FEEDBACK

name just two. This type of utility should permit reading characters from your serial card without restrictions, although you may have to experiment to get the exact procedure that will be successful.

I've never published a project article for an Apple serial interface card, but one by Richard Campbell did appear in the April 1979 issue of BYTE ("Cross-Pollinating the Apple II"). It describes a serial interface based on the Intel 8251 PCI chip. You could construct this interface as described, or readily update it by using a 6551 or 2661 serial chip. The latter two have on-chip oscillator components and internal data rate generators; you only need a crystal and a few passive components to complete that part of the circuit. You should also use a transceiver (e.g., the 74LS245) between D0–D7 on the bus and the corresponding pins on the serial IC. You might also want to look into constructing a dual serial interface card using the newer 2681 DART.—Steve

Graphics Woes

Dear Steve:

I have an IBM PC XT clone computer with a Hercules-compatible monochrome graphics card. However, this card will not work with the medium- and high-resolution BASIC commands (e.g., LINE, CIRCLE). These BASIC commands allegedly work only with the CGA card. I would like to write some BASIC graphics routines to output to a monochrome monitor.

Hercules HBASIC only works with a true IBM (since it makes IBM ROM calls), not with a clone. Has anyone written assembler routines that would allow BASIC access to Hercules-compatible graphics?

Alternately, is it possible to output CGA graphics (medium or high resolution) to a monochrome monitor? (My monochrome monitor is TTL.) If this is possible, I wouldn't have to buy a new dual-frequency monitor.

Stephen Goldfarb
Oakland, CA

First, don't even try to adapt your TTL monochrome monitor to accept CGA output. The monochrome monitor is not compatible with the sweep frequencies of the CGA. The result would be a burned-out component in the power supply.

You can write assembly language subroutines and call them from BASIC with the CALL( ) *statement. With interpreted BASIC, you would have to* BLOAD *the subroutine, or* POKE *it directly into memory. The IBM BASIC manual has a section on using DEBUG to set up addressing so that the subroutines can be loaded into high memory as .EXE files.*

Another method is to write BASIC programs to calculate the dot positions, use the DEF SEG *command to reference the beginning of the Hercules graphics memory, and* POKE *values directly into memory. According to the Hercules manual, the addresses are calculated from column/row (X,Y) coordinates using a formula of the form:*

```
offset = 2000H * (Y MOD 4)
       + (90 * INT(Y/4))
       + INT(X/8).
```

This is the address of the byte containing the dot you want to plot. The value of the byte to POKE *is determined by converting the value of 7 − X MOD 8 to a power of 2 (i.e., if X MOD 8 is 0, the bit is the most significant bit in the byte—bit 7; if X MOD 8 is 1, the bit is bit 6; and so on down to the least significant bit).*

Interfacing is much easier if you compile your BASIC program with the Microsoft QuickBASIC compiler. This allows you to write the subroutines and BASIC programs as separate modules whose addresses will be resolved at link time. The QuickBASIC manual shows how to set up the subroutines so that parameters will be passed to and from the machine language subroutine correctly.

The Hercules manual contains the information you need to determine how to plot graphics points where you want them, and how to switch the controller to graphics mode.—Steve

CIRCUIT CELLAR FEEDBACK

Programming While You Wait

Dear Steve:

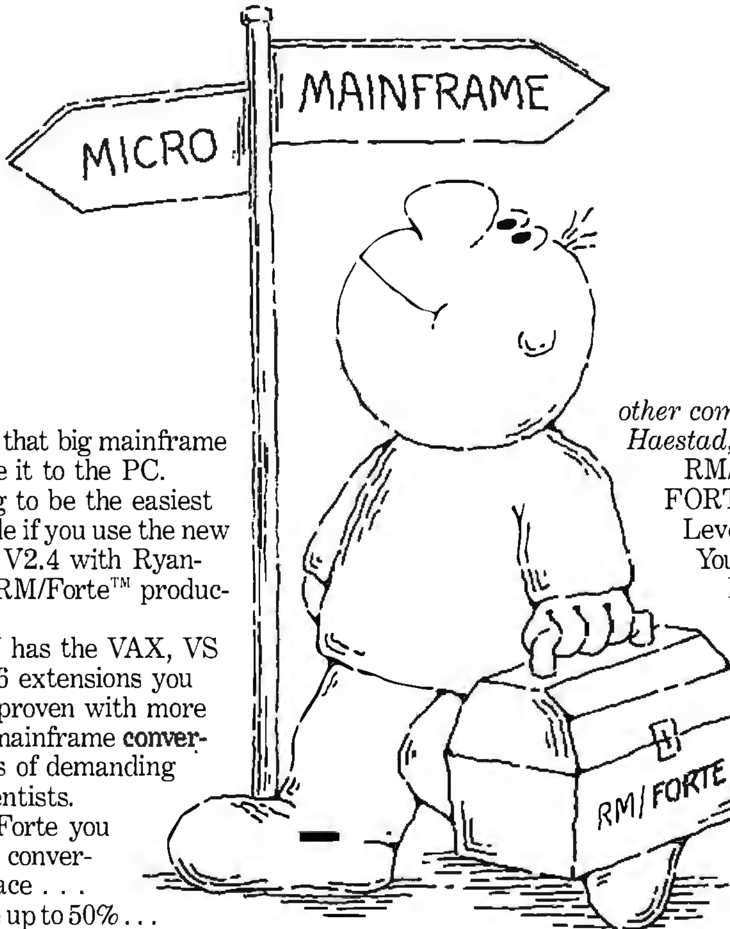
I am in the process of building a Z-80-based computer from scratch, using my own design. I will be using a 27C64 EPROM to execute the power-up self-tests and hexadecimal debug routine for data entry from a terminal. This will allow me to write and debug machine-coded programs for future use in other design applications. I like your EPROM programmer project in the October 1986 Circuit Cellar. However, as cost is a concern, I wonder what it costs these days to have an EPROM programmed, and where a person might go to have it done?

Allen Speer
Missoula, Montana

Most large electronic distributors will program EPROMs, PROMs, PALs, and so on, for a fee. This service is usually made available to their volume purchase

continued

FORTRANS-MIGRATION.



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customers. Most of the distributors I have a working relationship with let me use their programming equipment when I need a PROM, PAL, or some other device programmed that my programmer doesn't support.

If you are programming devices as part of a hobby, you probably won't get this type of service from a distributor. However, you might at least ask. Programming fees range from around $0.50 to $5, depending on the device and the way you supply programming information.

If you can't find a distributor in your area that is willing to program your devices, try a local college with an engineering department or seek out a computer club.

You will find that not having access to a programmer and eraser on your bench is a bother. If you develop code, run to a distributor for programming, wait for the turnaround, and find that your code has a bug in it so you have to repeat the whole process, you'll discover that a programmer is worth more than the money you save having someone else program the device.—Steve

Musical Floppies

Dear Steve:

I was recently going through some old magazines when I came across a small, one-page article about a digital audio recorder that uses floppy disks as a recording medium. Do you think this would be a candidate for a future Circuit Cellar project? I can envision a similar recording device based on the SB180, using a 3½-inch disk drive for storage with an RS-232C port for interaction with a home computer. I own a compact disk player and I think that a digital recorder would be an ideal enhancement to my home audio system.

Todd R. McMahon
Zurich, Switzerland

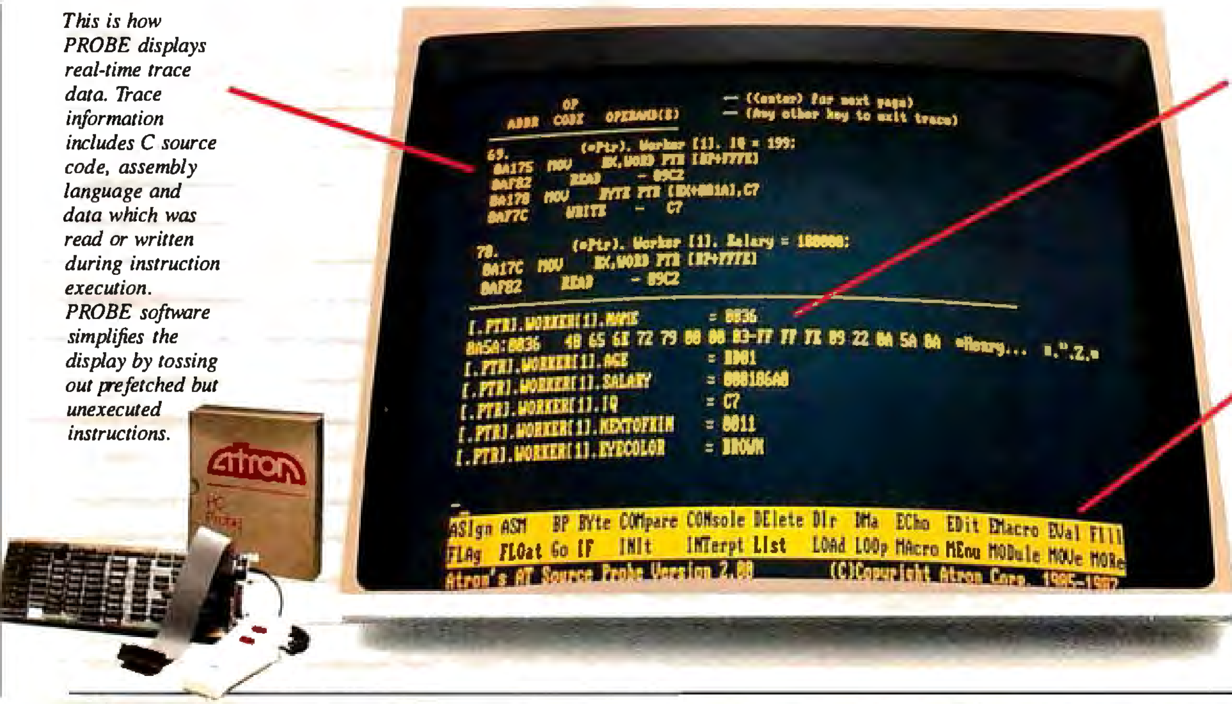
Thanks for your suggestion for a Circuit Cellar project. OKI Semiconductor in Sunnyvale, California, has recently announced the MSM6258 speech-processor chip, which may allow construction of the device you mentioned. The chip can be configured into a solid-state audio recorder and can use static or dynamic RAM, ROM, or EPROM for storage. I am reviewing this chip, and if feasible I will include it in a future article.

Another approach is a new digital audio tape-recording system (called DAT for short) that will soon be introduced to the consumer market. It uses a rotating head, just like a videotape recorder, with a (roughly) ¼-inch tape in a cassette similar in size to conventional analog audio-

continued

WHO YA GONNA CALL? BUGBUSTERS!

This is how PROBE displays real-time trace data. Trace information includes C source code, assembly language and data which was read or written during instruction execution. PROBE software simplifies the display by tossing out prefetched but unexecuted instructions.



PROBE knows all about your local and complex variables. You can display and change an array of structures as easily as shown in this display.

PROBE's menu window means you do not have to look up debug commands in the manual. Entering the command name shows you command syntax.

"Real-time source-level debugging of very large programs simply can't be done without Atron's AT PROBE." *Ed Oates, Director of PC Software Development, Oracle Corporation*

The good news with your new Microsoft 4.0 or Lattice* C compilers is that they're providing more symbolic debugging information than ever. The bad news is you can't fit your program, a software debugger and that monster symbol table into memory - at least at the same time.

The great news is that Atron's AT PROBE™ hardware-assisted software debugger not only has 1-MByte of onboard memory for debugger and symbol table, but it now supports local variables and complex data types.

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The AT PROBE's hardware-assisted breakpoints trap on reading, writing, executing, inputting and outputting. On single or ranges of addresses, including particular variable values. All in real time. For a mere software debugger to attempt this, a 1 minute program would take 5 hours to execute.

OPTIMIZED CODE - GOOD, BAD AND UGLY

The good news is optimizing compilers generate very tight code. The bad news. The time to debug optimized code is inversely proportional to the quality of the optimizer. Figuring out how in the world you ended up somewhere gets ugly, fast.

With AT PROBE's real-time trace capability, program execution history is saved on-board, in real time. Once a hardware trap has occurred, PROBE displays the program execution in detail, including symbols and source code. Real-time trace can show you how out-of-range pointers got that way. And there's really no other way to debug interrupt-driven code.

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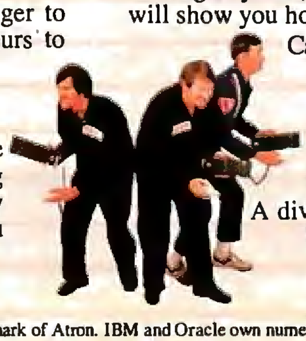

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tape. Given the economy of scale of consumer hi-fi equipment (look at how compact disk machines have fallen in price since their introduction), I think that I would rather wait until this technology is established.

There could be quite a number of interesting applications built around a commercial DAT machine, at far lower cost than using conventional data storage devices such as disk drives.—Steve

Reusable Computers

Dear Steve:

I believe that at one time you were the owner of a Digital Group computer, as I was. You'll remember that if you wanted to change processors all you had to do was unplug the processor board and plug in another. All the other boards in the system recognized the same signals on the same pins, so that, in principle, no matter what innovations came out all you had to do was change a single board.

Isn't this idea still viable? What makes me remember the Digital Group machine with nostalgia are all these new chips that sound so interesting but that I will never be able to afford—the 80286, 80386, 32032, the 68020, not to mention all the new graphics chips. It seems that if I want to indulge my hobby to the utmost, every two years I will have to throw away whatever machine I currently own and buy another. Don't you think it would be a good idea if you were to design a Digital Group–like machine that would keep me (and thousands like me) abreast of the latest advances in hardware?

M. Kreiger
Brooklyn, NY

The concept of bus architecture is alive and well. The IEEE-696 standard, better known as the S-100 bus, offers the possibilities you desire. Although some may think that the S-100 bus is more of a relic than new technology, there are 8088-, 6800-, 6500-, and 68000-based processors available in S-100 boards that support peripherals as defined by the IEEE-696 standard.

Unfortunately, the S-100 bus machines have become the domain of the small-business user, losing hobbyists and home users to the much simpler and ready-made technology of the IBM PC, Commodore, and Atari machines. Perhaps coverage of S-100 projects warrants consideration—it is the base upon which BYTE was built.—Steve

An SB180 in a Kaypro?

Dear Steve:

I have watched the development of your SB180 8-bit computer system with

continued

interest, particularly inasmuch as I own three 8-bit Kaypro computers and plan to keep them for some time. Since there are tens of thousands of Kaypro 2s, 4s, and 10s out there, have you considered making available a "plug-compatible" SB180 for these machines?

There wouldn't have been much of an advantage in doing so when the SB180 was running at 6 MHz, but at 9 MHz such a replacement would benefit many.

I would imagine that the changes to the SB180 and associated software would be rather minimal: such changes as allowing the use of the Kaypro CRT as is, perhaps software changes to make Kaypro the standard floppy format, and (for the Model 10), changes to allow the use of the extant hard disk controller and hard disk. The operating software might also require a few modifications so that standard Kaypro software (which expects an ADM 3A monitor) would run as expected.

What do you think?

Norman Buchignani
Department of Anthropology
The University of Lethbridge
Lethbridge, Alberta, Canada

I currently have no plans to build a "plug-compatible" version of the SB180 that could be installed in the Kaypro 8-bit machines.

The SB180 can easily be used with an existing Kaypro by using an appropriate terminal program, such as the public domain MEX, running on the Kaypro to make it into a terminal for the SB180. The SB180 distribution software allows you to specify any of a number of terminals to be used with the SB180. This method would not be exactly what you requested, but would provide the SB180 advantages at moderate cost while retaining all of your present Kaypro features. The SB180 can read and write Kaypro II format disks. —Steve ■

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, at the end of Ask BYTE I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.

If you would like to share the knowledge you have on microcomputer hardware with other BYTE readers, joining the Circuit Cellar/Ask BYTE staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.

If you're interested, let us hear from you. Send a short letter describing your areas of interest and qualifications to Steve Ciarcia, P. O. Box 582, Glastonbury, CT 06033.

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IBM Personal System/2 Model 30

IBM Personal System/2 Model 50

Model 30 is about 25% smaller than the IBM PC, does many jobs more than two times faster than the IBM PC XT,™ and comes with 640KB of memory and a 20-megabyte (MB) fixed disk if you want one. Much of what used to be optional is now standard, and improved. Graphics are spectacular. So is the value. Model 30 offers exceptional performance for the money.

Model 50, with its 80286 microprocessor, is an even bigger step forward. It has new architecture (as do the even more powerful models) that breaks old barriers. One megabyte of memory is now standard, and there's plenty of room for more. Its graphics (again, in common with the larger models) are another dimension beyond. And it finishes many jobs significantly faster than the IBM Personal Computer AT.®

Model 60 takes up less space on your desk because the computer itself doesn't sit on your desk, but rather, beneath or beside it. Equipped with a 44 or 70MB fixed disk, up to 15MB of memory and expanded expandability, it's a system for serving a very busy person, and can be a file server for

personal computing.

other busy persons.

Model 80. For everyone who's been waiting to experience the real power of the 80386 microprocessor, it's not just *in* this computer, we built this computer around it. Available this summer, Model 80 is a 32-bit system that does jobs up to

The rest of this booklet tells more about the IBM Personal System/2. And how, all together, it can help make your professional life easier, more productive, and more rewarding.

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IBM Personal System/2 Model 60

IBM Personal System/2 Model 80

three and a half times faster than the IBM Personal Computer AT. Up to 2MB of memory are standard, and fixed disks can be 44, 70 or 115 megabytes big. Or with two fixed disks, 230 megabytes huge. Computers this capable, and connectible, used to fill whole rooms.

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The new graphics.

You'll see new graphics, all standard, that redefine the words

"colorful" and "sharp." And new displays that give your programs a heightened sense of reality.

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There will be new avenues for sharing information; new match-ups of hardware and software that shorten the distances and widen the roads between PCs, minis, mainframes and people.

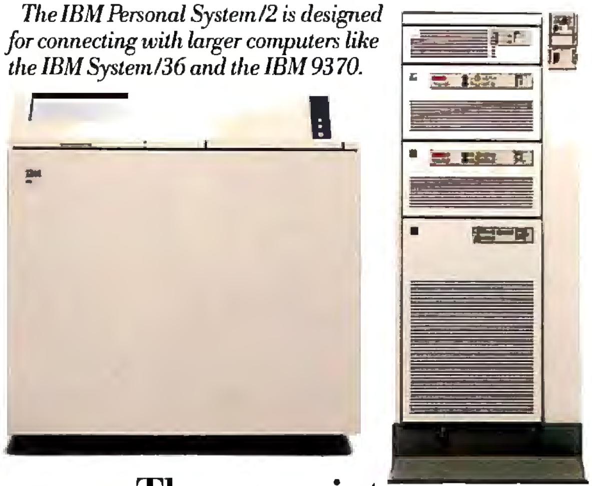
The new media.

You'll see rugged diskettes that are half as big, but hold up to twice as much as floppies did. Plus low-cost devices for transporting your data from one generation into the next. And a new IBM 200MB optical disk drive.

The new solutions.

You'll discover new ways to solve problems; ideas about choosing not just software or hardware, but software, hardware and support in balance.

The IBM Personal System/2 is designed for connecting with larger computers like the IBM System/36 and the IBM 9370.



The new printers.

You'll see an expanded family of personal printers that fills just about any need, from economy, to speed, to the fussiest levels of document quality.

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And because it's not just what you buy but where you buy it, you'll learn how we've been working closely with the people who sell the Personal System/2 to create new levels of dealer support.

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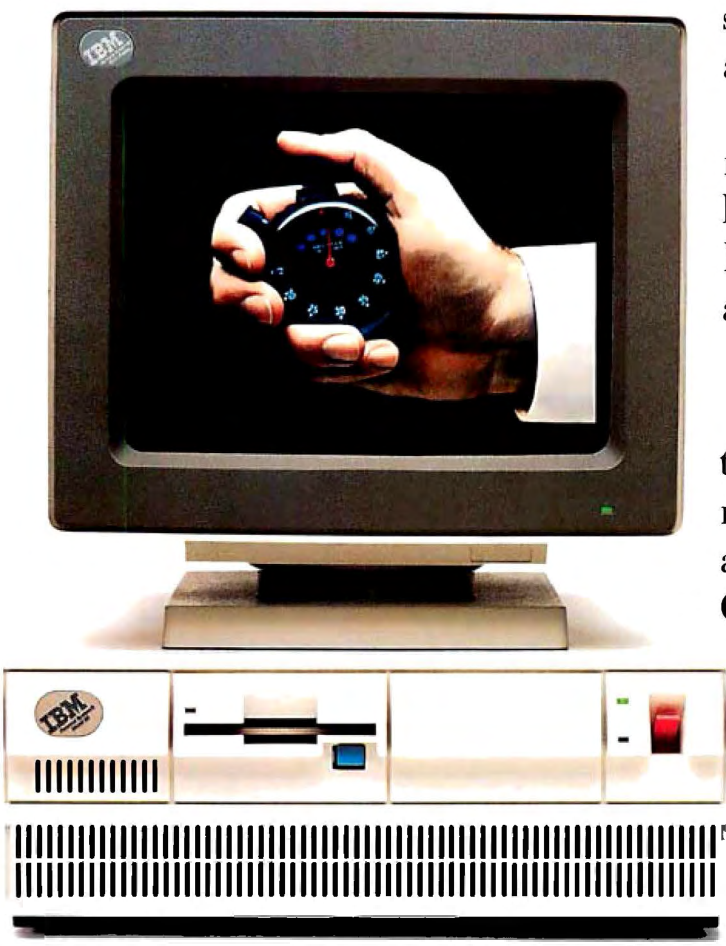
The new performance.

It's tempting to size up computers by the numbers, but in the IBM Personal System/2, real performance exceeds the sum of its parts.

Components were designed not just to coexist, but to cooperate; within each system, and within your total computing environment.



The IBM Personal System/2 takes up less space on your desk. The on/off switch is on the front, and monitors tilt and swivel.

So your software runs faster, and your system is more reliable.

Extras aren't extra.

You could expand earlier IBM PCs after you bought them, but the Personal System/2 is expanded before you even open the carton. Things that used to cost extra don't anymore.

Advanced graphics, parallel and serial ports, a port for pointing devices, and diagnostics are included.

And new IBM technology—our one-million-bit memory chip, high-density logic circuits, and integrated "planar boards"– is sending performance up, and costs down.

Paths to the future.

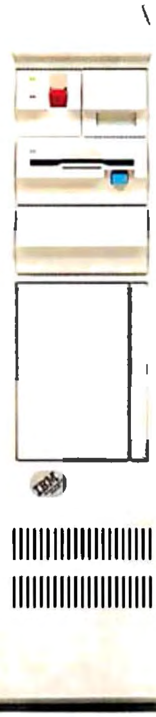
Models 50, 60 and 80 share a design that's new to personal computing. Technically it's described as parallel bus architecture (we call it IBM Micro Channel™), but think of it as a highway.

Our first PCs were built around a two-lane street. Usually that's enough, but sometimes there are traffic jams. Your sales figures might have to stand on the corner while your mailing list goes by.

The new system is like an expressway. There are more lanes open t?

The ramps are more smoothly paved, and signals are better synchronized. So data can flow more freely.

This is what the 286 and 386 chips have been waiting for. A highway to match their horsepower.

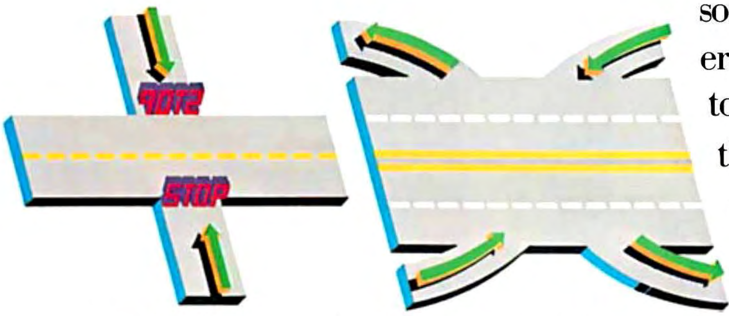


The IBM Personal System/2 Model 80 was created to unleash the power of the 80386 microprocessor.

The new operating systems.

The Personal System/2 is being introduced with a new IBM PC DOS Version 3.3 that lets you tap into the new systems immediately, and works with all previous IBM PCs as well.

There's also an IBM 3270 Workstation Program that, with PC DOS Version 3.3, helps the Personal System/2 connect with



In earlier PCs, data sometimes had to stop and wait. New IBM Micro Channel architecture is more like an expressway. Data flows more freely.

mainframes, supports more memory, and lets you run multiple applications.

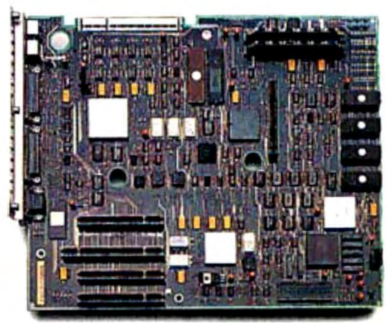
But much more is coming.

A new IBM Operating System/2™ will run on Models 50, 60 and 80. Available later on, its development is involved—software makers, our dealers, you—can take full advantage of its power as easily as possible. It will do everything our existing PC DOS does (in fact, they'll get along beautifully), but it also will bring major advances.

Memory. Our new systems offer up to 16 megabytes' worth, and Operating System/2 will make these vast resources easier to access.

Multi-tasking. With IBM Operating System/2, you won't have to be a "power user" to understand how to run several programs at once. Multi-tasking will become a routine experience.

Software. Together with the new architecture and more memory, Operating System/2 will give software developers new freedom to create programs that are more powerful, better looking, and easier to use than ever before.



IBM Personal System/2 "planar boards" have many standard features that used to be options.

A bigger idea. Operating System/2 is also part of another new idea, called IBM Systems Application Architecture.

Its goal is to bring the world of IBM computing closer together; to provide a greater consistency in look, function and feel—for systems, for software and for people who use them. IBM Operating System/2 is the first step for personal computing in this promising new direction.

It's like having 256,00
in one box.

The new graphics.

Back in the dark ages of personal computing, the world was ruled by numbers and words. Graphics were a nicety, but rarely a necessity.

Welcome to the Renaissance.

The IBM Personal System/2 has a talent for graphics that's dazzling.

Each new system can paint up to 256 colors on the screen at once, drawing from an incredible palette of over 256,000. And not one of those colors costs a penny extra.

The IBM Personal System/2 Monochrome Displays 8503.

Even in monochrome, things aren't monotonous. There can be up to 64 shades of gray for new dimension and contrast.

And the images themselves are greatly improved. The tiny "pixels" that create the image can now be tinier, and there can be lots more of them. Even the space between them seems to have disappeared. So pictures are

All screens in this brochure are actual and unretouched.

0 crayons

sharp and clearly defined.

Better letters.

Equally important, letters and numbers are clean-edged and precise,

The IBM Personal System/2 Color Displays 8512.

The IBM Personal System/2 Color Displays 8513.

looking more like they're printed than projected. After a few hours with your trusty spreadsheet, you'll appreciate that.

You'll also like the non-glare viewing surface, and mountings that tilt and swivel so your neck doesn't have to.

There are four new IBM displays, and each works with every Personal System/2 computer, all showing graphic improvements in price.

The 12″ monochrome and 14″ color displays are great for most general-purpose work. The 12″ color display is even sharper, ideal for detailed business graphics. And for design work, there's the big 16″ color display with even higher resolving power.

Your favorite programs.

Just about any program you can run on the IBM Personal System/2 will look better, and will likely be more pleasant to spend time with. Many other programs are being reworked just to take advantage of the new graphics.

But the future holds real surprises. The screens of the Personal System/2 are like a brand new kind of canvas. How the artists will use them should be something to see.

The IBM Personal System/2 Model 50 and the IBM Personal System/2 Color Display 8514.

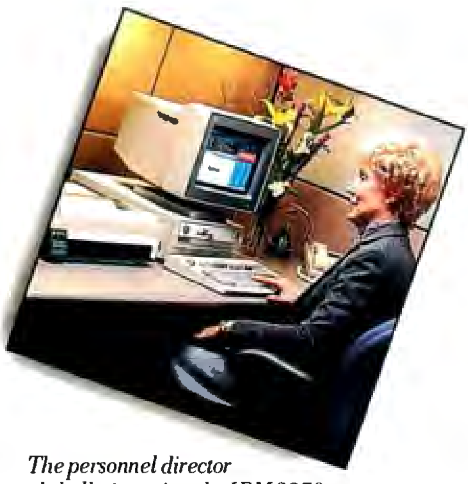
The future belongs to well-connected.

The new connectivity.

The earliest computers were big and costly, so people shared them.

Then people wanted smaller computers just for themselves. Soon PCs were in offices everywhere. And how did people want to use them?

The managing director uses IBM 3270 Emulation and Professional Office System™ software (PROFS) for checking calendars and sending electronic mail.



The personnel director sends bulletins using the IBM 3270 Workstation Program and PROFS.

For sharing things. So the idea of PC connectivity was born.

From the start, the IBM Personal System/2 was designed to connect; with other IBM personal systems, with bigger IBM systems.

Each new system comes with built-in asynchronous communications (which can save you an option slot for other uses).

An executive assistant uses IBM DisplayWrite 4 to polish up memos and reports for distribution through IBM DISOSS.

An inventory clerk uses an inquiry to a data base to compare what's out in the warehouse with sales orders.

the

A product manager loads her spreadsheet using the IBM Token-Ring Network to access information.

So information has no trouble traveling back and forth. But the real news is what happens inside.

Going with the flow.

The new architecture in Models 50, 60 and 80 will improve the flow of traffic within the system, so when an important message comes in from corporate headquarters, it's less likely to see stop signs. And if the sender has a properly equipped IBM PC, PC XT, Personal Computer AT or IBM Personal System/2 Model 30,

The IBM 9370 computer stores information and provides data base management support for the business.

that's okay too—they work together.

And as the new IBM Operating System/2 unfolds, communication will become even easier. Its multi-tasking capability will make it easier for your system to receive and store electronic mail, mainframe data, or whatever, while you're busy doing something else.

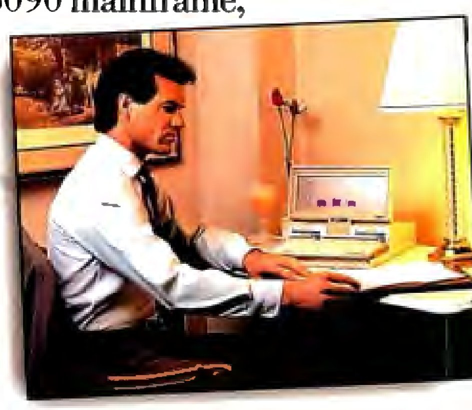
The scope of communication has been increased, too.

A wide array of local area network and connectivity products is part of the IBM Personal System/2 family, so your resources can be as broad as your needs; from the first IBM PC your company ever bought, to mid-range systems, to the biggest IBM 3090 mainframe, the lines are open.

And this is just the beginning.

Programmers work within the framework of IBM Systems Application Architecture to develop applications.

A design engineer uses an IBM Personal System/2 Model 80 to create a product accessing designs from the host computer.



Meanwhile, from a hotel room, a salesman uses the modem in his IBM PC Convertible to send back details of a new order.

IBM just got smaller. three quarter inches.

The new media.

The amazing 5¼″ floppy diskette can hold literally hundreds of pages' worth of memos, reports and vital statistics.

So why are we switching to 3½″ diskettes?

Because they hold up to twice the information, and they don't flop. A hard plastic case protects them from mishaps that floppies are heir to.

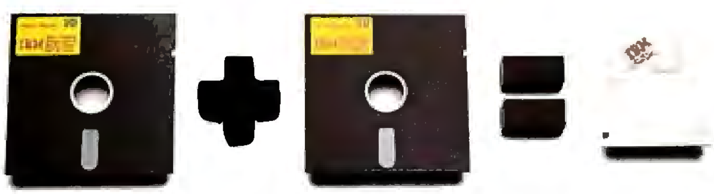
A simple accessory kit transports data from 5¼″ to 3½″ diskettes.

So not only can you slip a diskette into your shirt pocket, you'll have fewer of them, with more of your work all in one place. You won't have to fool around with write-protect tabs anymore, either. They're built right in.

Bridging the gap.

Very nice, you say, but what about all that work on 5¼″ diskettes?

We thought about that from the very beginning, and we're offering a number of low-cost solutions to make the transition as smooth as possible.



It takes two 360KB 5¼″ diskettes to hold as much as one 720KB 3½″ diskette.

One is a simple cable adapter and software package that lets you send your data from an IBM PC, PC XT or Personal Computer AT to your IBM Personal System/2, then onto the smaller diskettes. Depending on how much data you have, the whole job could be over in one sitting.

Also available are special IBM 3½″ and 5¼″ external diskette drives, to be there

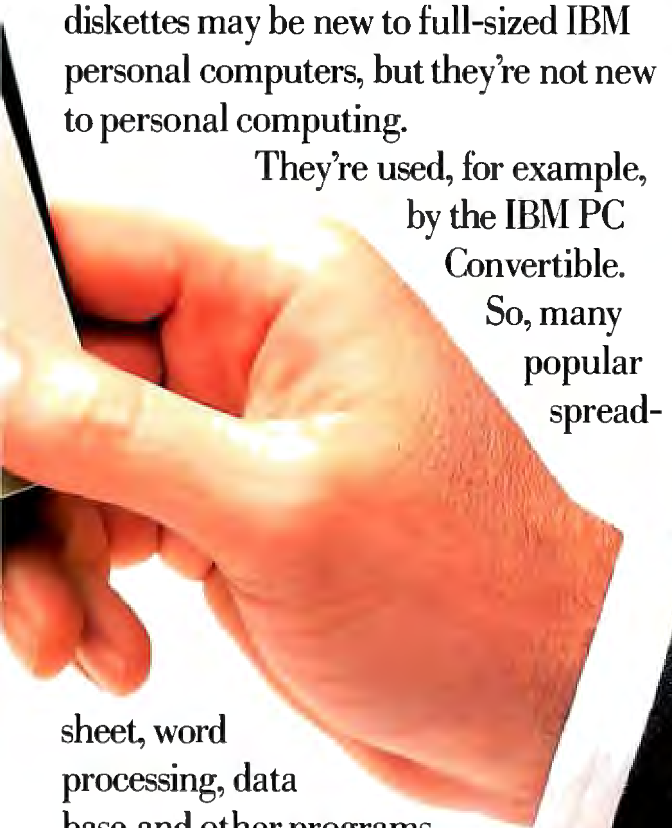
By one and

anytime you need them, for conversions in either direction.

Software is here.

And what about software? Well, 3½″ diskettes may be new to full-sized IBM personal computers, but they're not new to personal computing.

They're used, for example, by the IBM PC Convertible. So, many popular spread-sheet, word processing, data base and other programs (from IBM and other companies) are already available on 3½″ diskettes. And software makers are working to get new releases out quickly.



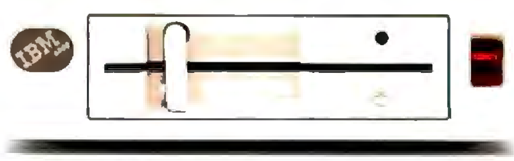
Optical allusion.

If a 3½″ diskette can store large amounts of information, here's a way to store gargantuan amounts.

We're introducing a 200-million-byte optical disk drive.

It works with all Personal System/2 computers and, with advanced laser technology, will let you build a massive library of information for business, science and education on removable disks you can hold in your hand.

The IBM 3363 Optical Disk Drive with "write-once, read-many" disks (left) and the IBM 3.5 Inch External Diskette Drive (right).



The IBM 5.25 Inch External Diskette Drive.

The solution is part o
system.

The new solutions.

We sell computer systems, but that's not what you're really after.

You want the things a system can do for you.

So while we were busy developing new machinery, we were also active on the software front.

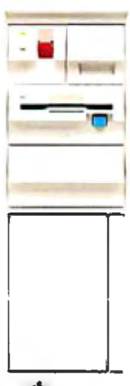
One of the first things we looked at was how you choose software.

Over the last five years, thousands of programs have been written—by us and by others—for IBM PCs. That's a good thing, and we want to keep it going, so we've continued to work with independent software companies.

Getting with the program.

We're telling them about our move to 3½″ diskettes so they can convert popular programs to that size. We're showing them our new graphics so they can revise software to take advantage of them. And we're keeping them up-to-date about the new IBM Operating System/2 so they can create brand new programs with even higher levels of function.

IBM CADwrite Design and Drafting System SolutionPac for designers and engineers.



So, popular programs like Lotus 1-2-3,™ WordPerfect® and dBase III PLUS™ will be available for the Personal System/2.

f the

Needless to say, we've also updated our popular IBM software. IBM DisplayWrite™ 4, the IBM Assistant Series,™ IBM Business Adviser* and IBM educational programs are ready to go for the Personal System/2.

The IBM SolutionPac.™

Then we looked at software from another point of view.

With so many decisions to make, so many combinations of hardware and

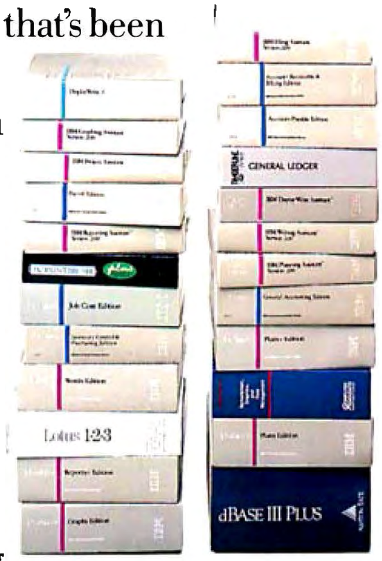
IBM Business Adviser Financial Accounting SolutionPac.

software, choosing the right one can be confusing. Maybe you'd prefer "one-stop shopping."

So we created an idea called IBM SolutionPacs.

You'll be able to buy them from selected IBM Authorized Advanced Products Dealers.

What you'll get is a software package designed for your kind of business, with a hardware ensemble that's been matched to it, and tested. Plus a program of service, training and support.



Popular programs will be available for the IBM Personal System/2.

A wide range of IBM SolutionPacs is in the works. Among the first ones available are the Business Adviser Financial Accounting SolutionPac, a CADwrite Design and Drafting System for designers and engineers, a desktop publishing SolutionPac and a Doctor's Office Management package, as well as SolutionPacs for contractors and lawyers.

They will make buying easier, and should shorten the time between "I've got my computer system" and "I've mastered my computer system."

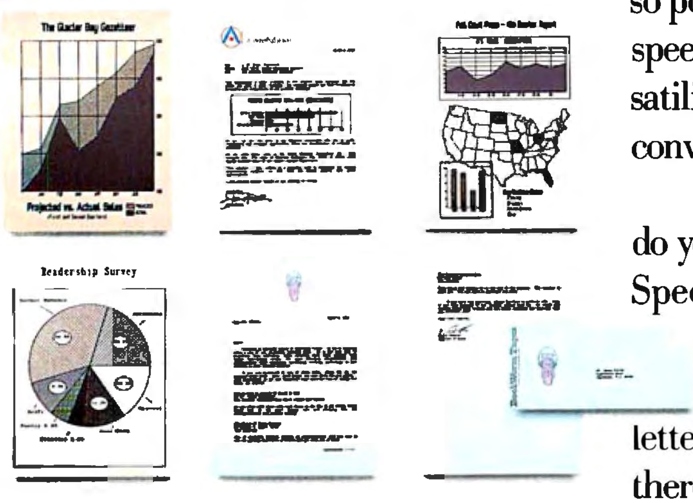
Of course, a big role is played by the new Advanced Products Dealers. Their new "whole-solution" training will make it easier for the two of you to assemble the best system for you.

*ADVISER is a registered trademark of Computer Designed Systems, Inc., Minneapolis, Minn.

New power to the prin

The new printers.

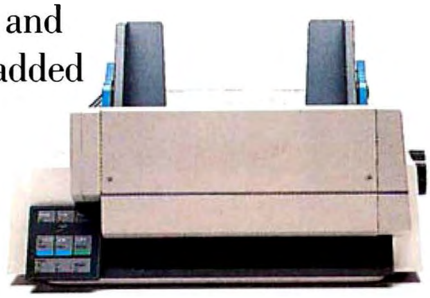
Most of what shows up on your computer screen is seen by just one person. You.



But what comes out of your printer goes out to the world. So it has to look professional, and getting it done has to be easy; virtues that have made IBM personal printers best-sellers.

The IBM Proprinter™ and the IBM Quietwriter® Printer have earned high marks from both customers and critics.

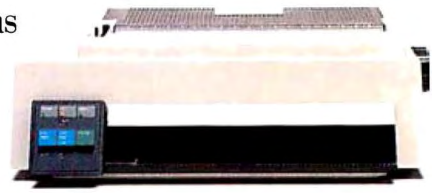
Now our printers are even better, and we've added new members to the existing family.



The IBM Proprinter X24 with optional sheet feed.

The IBM Proprinter II.

What made the original Proprinter so popular was speed, versatility and convenience.



The IBM Proprinter II.

So what do you get more of in the Proprinter II? Speed, versatility and convenience.

fast

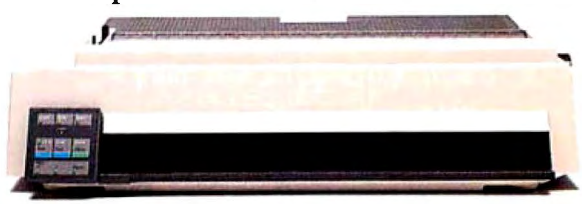
letter quality" is faster too, because now there's a button for changing modes.

There's also a choice of typestyles, and of course you can still load envelopes from the front and put in single sheets any time you want.

The IBM Proprinter II is for anyone who wants to print text and graphics, with a printer that's fast and economical.

The IBM Proprinter X24 and Proprinter XL24.

The IBM Proprinter X24 and Proprinter XL24 are new. The "24"



The IBM Proprinter XL24 has a wide carriage, ideal for spreadsheets.

ted page.

stands for 24-wire technology. What *that* stands for is new levels of Proprinter quality for everything you put on paper.

Both models print letter quality text with greater detail and graphics with better density and definition. The improvement is easy to see.

So is the performance. When compared to current, best-selling, comparably priced 24-wire printers, the Proprinter X24 and Proprinter XL24 print 1½ to 2 times the draft output in the same amount of time.*

The Proprinter XL24 has a wide carriage for spreadsheet printing, and both have an optional sheet feed for added paper-handling convenience, plus FontSet,™ an option that lets you choose from 11 other typestyles.

The IBM Quietwriter III Printer.

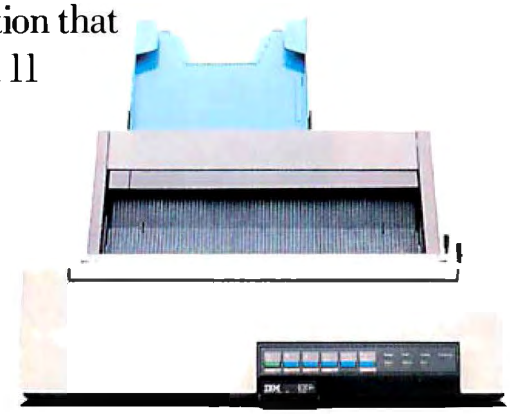
Earlier IBM Quietwriter printers have always been easy on the ears, but the new IBM Quietwriter III Printer is even quieter and goes nearly twice as fast, printing executive letter quality text and graphics in an executive hurry.

There's new flexibility in style, as well. The Quietwriter III Printer comes with four different type fonts built in and you can combine typestyles within the same document.

If that's not enough, there are optional font cartridges that give you the freedom to use up to eight typestyles on one page.

There's also a new dual-drawer sheet feed (with optional envelope feed) that lets you use letterhead stationery for the first page of a letter, then plain paper for the rest.

No matter what level of price or performance you need, there's an IBM personal printer to fit the bill. And they fit very nicely with the IBM Personal System/2.



The IBM Quietwriter III Printer with single-drawer sheet feed.

There's also an innovative multiple-drawer sheet feed.

*Based on an independent evaluation using *PC Magazine* Labs Benchmark Series.

It's not just what you b but where you buy it.

The new support.

As we designed the IBM Personal System/2, we weren't just thinking about products. We also paid serious attention to how, and where, you buy them.

The IBM Personal System/2 offers so many possibilities, so many new ways to do things better, astute guidance must be there if you need it.

So we're raising the bar for customer support. Naturally, our IBM Marketing Representatives are fully knowledgeable about the Personal System/2. But also, we're bringing even greater levels of support from our dealers to you.

IBM Authorized Advanced Products Dealers.

Announcing the new IBM Authorized Advanced Products Dealers.

Selected from our already outstanding dealers, they're being specially trained and qualified. They will have the IBM Personal System/2 computers, IBM network and connectivity products, peripherals, new IBM Operating System/2 when it's available, and all the support you should need.

Perhaps even more important, they'll have a new focus; on systems instead of single pieces of hardware, on solutions instead of circuitry.

They'll be thinking not only about the system you buy, but also about how you'll be using it.

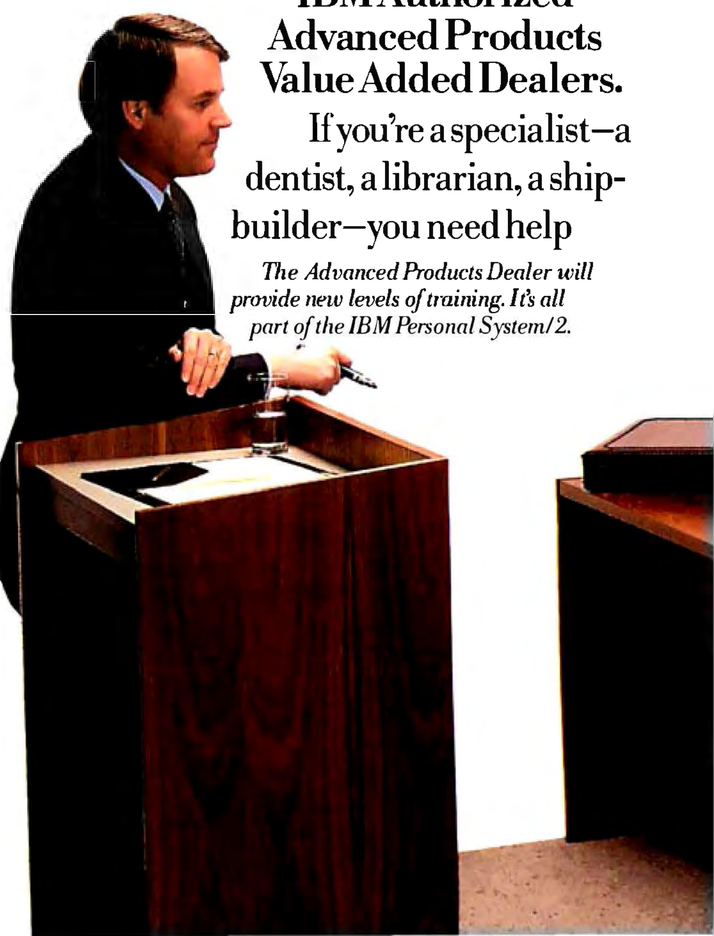
They'll offer help with learning about systems and software, connectivity, and Operating System/2.

And they're committed to new standards of training for their sales, technical support, and service people.

No matter how big your business, whether you need one computer or a whole network's worth, the Advanced Products Dealer has what you need.

IBM Authorized Advanced Products Value Added Dealers.

If you're a specialist—a dentist, a librarian, a shipbuilder—you need help



The Advanced Products Dealer will provide new levels of training. It's all part of the IBM Personal System/2.

uy, from a special kind of dealer.

Introducing the new IBM Authorized Advanced Products Value Added Dealers.

They're specialists, too. They build enhanced systems for specific industries and now, with the entire Personal System/2 family, their building blocks are better than ever. There's an Advanced Value Added Dealer who understands your business almost as well as you do.

IBM Authorized Dealers and Value Added Dealers.

Our IBM Authorized Dealers and Value Added Dealers will have the IBM Personal System/2 Model 30 and peripherals to go with it, plus special know-how for helping people get started in computing.

IBM Marketing Representatives.

These people have special skills for helping large companies and educational institutions make the most of their investment in the IBM Personal System/2.

And now, through the IBM Customer Fulfillment Option, our customers may also work with our dealers and value added dealers to get the best of both worlds; additional support for the Personal System/2 plus the benefits of dealing with IBM directly.

Congratulations are in order.

It's not easy to qualify (and stay qualified) as an Advanced Products Dealer. Our expectations are high, as high as yours are.

So when you visit one of our Advanced Products Dealers, give them a nice pat on the back. They've just signed up for a tough course.

A system that's bigger sum of its parts.

A new direction.

The IBM Personal System/2 arrives in the wake of some fairly eager public speculation. So we expect there'll be a focus on "the new IBM PCs."

But our focus is different.

IBM's one-million-bit memory chip joins the world of personal computing.

While the machines are certainly key to the system, they are not The System.

It's bigger.

And it begins, not with chips or circuit boards, but with you. After all, if our products don't answer your needs, you don't need them.

So everything about the Personal System/2—how we build it, how you learn and use it, where you go to buy it, and how well it works with your other systems—is balanced to give you the highest overall performance.

A new quality.

We're making the Personal System/2 even more reliable than our earlier PCs.

With new Very Large Scale Integration technology, many pieces in a system are now replaced by one piece. Our one-million-bit memory chip reduces complexity, too. So costs go down, dependability goes up, and you get more work done in less time.

We're also using more IBM-made components, and we're subjecting our systems to more rigorous testing.

We even operate each one for several hours before it goes out the door.

Yet in creating all this new technology, we didn't forget that three million earlier IBM PCs are out in the world. So our two generations are close relatives, and your investment in equipment and training is protected.

Nor did we forget that many of you have larger IBM systems. The Personal System/2 will help you build better connections with IBM mid-range and mainframe computers.

New help.

We've also made the Personal System/2 easier to learn. New IBM manuals, tutorial

than the

diskettes, and start-up procedures will help you get your system going quickly.

So will the people you bought it from. Our new Advanced Products Dealers and IBM Marketing Representatives won't just sell you the right system, they'll be there to help you get the most out of it. And as your needs grow, they'll be able to help you expand your system to meet new challenges.

Earlier IBM PCs and the new IBM Personal System/2 work together so your investment is protected.

A continuing tradition.

It's said in the world of computing that the only constant is change, but that's not entirely true.

In IBM's world of computing one thing holds firm, and it's the notion of partnership between our people and our customers. The Personal System/2 is a product of that partnership.

IBM people are some of the best listeners in the business, and when they hear what you want, they do something about it.

We're very proud of them all, and the more you know about the IBM Personal System/2, the more you'll understand why.

And now for the fine print.

All models include integrated display support, 256-color graphics capability, clock/calendar, and ports for serial, parallel and pointing devices. All systems use a common IBM enhanced keyboard and accept any IBM Personal System/2 monochrome or color display. All models accept the 200MB IBM 3363 Optical Disk Drive option.				
	Model 30	**Model 50**	**Model 60**	**Model 80**
Microprocessor	8086	80286	80286	80386
Potential system throughput[1]	Up to 2½ times PC XT	Up to 2 times Personal Computer AT	Up to 2 times Personal Computer AT	Up to 3½ times Personal Computer AT
Standard Memory	640KB	1MB	1MB	Up to 2MB
Expandable to		7MB	15MB	16MB
Diskette size and capacity	3.5 inch 720KB	3.5 inch 1.44MB	3.5 inch 1.44MB	3.5 inch 1.44MB
Fixed disk[2]	20MB	20MB	44, 70MB	44, 70, 115MB
Additional Options			44, 70, 115MB	44, 70, 115MB
Maximum configuration[3]	20MB	20MB	185MB	230MB
Expansion slots[4]	3	3	7	7
Operating system(s)	PC DOS 3.3	PC DOS 3.3 and Operating System/2	PC DOS 3.3 and Operating System/2	PC DOS 3.3 and Operating System/2

1. Based on the testing described in the IBM Personal System/2 Performance Guide. Your results may vary. 2. Model 30 also comes in a diskette-based configuration. 3. Models with 44MB fixed disk expandable to 88MB. 4. Model 30 accepts most IBM PC and IBM PC XT option cards. Models 50, 60 and 80 accept new IBM Micro Channel option cards.

Now that you've read all about the new IBM Personal System/2 and examined its specifications, what should you do?

Go to your telephone. Call 1-800-447-4700 (ext. 9) and you'll learn who's the IBM dealer nearest you. (In Alaska call 1-800-447-0890, in Canada 1-800-465-6600.)

And here are two things to ask when you finally get face to face.

Ask about an IBM Credit Card. It just makes buying that much easier for a person or a business.

Or, if you prefer leasing, ask an IBM authorized dealer or IBM Marketing Representative about the IBM leasing programs.

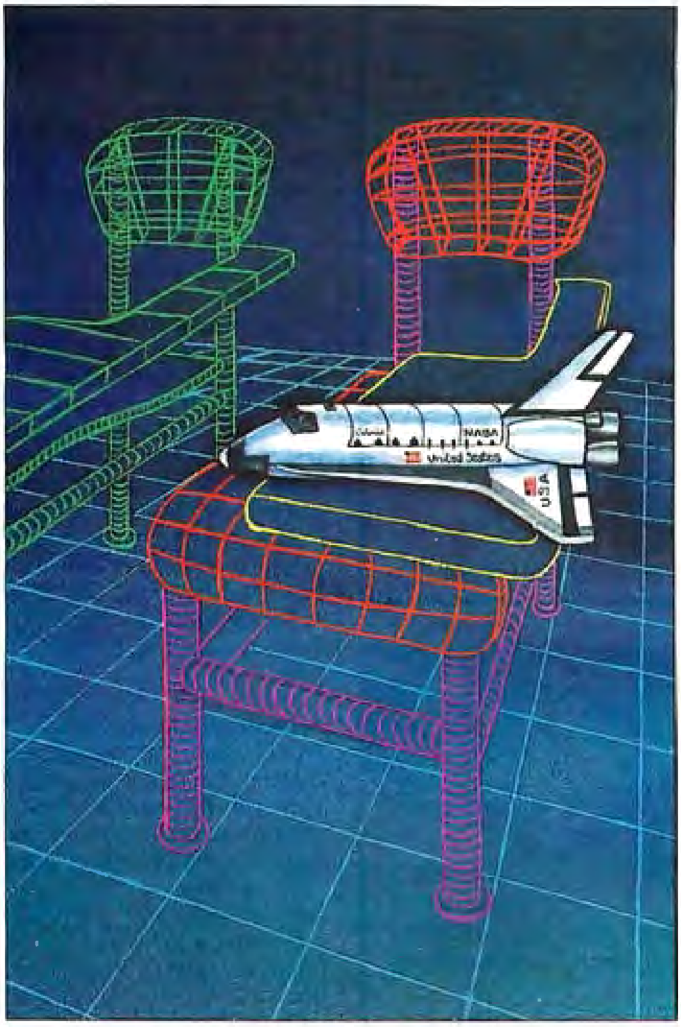
With those formalities out of the way, you'll want to join the next generation in personal computing. The IBM Personal System/2.

IBM®

THE AUTOCAD PRODUCTIVITY BOOK: TAPPING THE HIDDEN POWER OF AUTOCAD
A. Ted Shaefer and James L. Brittain
Ventana Press
Chapel Hill, NC: 1986
ISBN 0-940087-00-6
314 pages, $39.95

THE WORLD OF PROGRAMMING LANGUAGES
Michael Marcotty and Henry Ledgard
Springer-Verlag
New York: 1987
ISBN 0-387-96440-1
360 pages, $29.95

THE INGRES PAPERS: ANATOMY OF A RELATIONAL DATABASE SYSTEM
Michael Stonebraker, ed.
Addison-Wesley
Reading, MA: 1986
ISBN 0-201-07185
452 pages, $35.95



THE AUTOCAD PRODUCTIVITY BOOK: Tapping the Hidden Power of AutoCAD

Reviewed by Steven H. Rogers

The AutoCAD Productivity Book by A. Ted Shaefer and James L. Brittain is targeted at AutoCAD (a CAD program from Autodesk) users who have a basic knowledge of how AutoCAD works. For designers who use AutoCAD, this book contains techniques to customize and otherwise improve the performance of their AutoCAD systems.

The book has two main sections. The first is tutorial in nature, while the second is a library of AutoCAD macros and AutoLISP functions to make life easier for the AutoCAD user. relative newcomers to AutoCAD can proceed through the tutorial and perform the exercises it presents, while those more proficient in AutoCAD might skim it to try out the tools from the Productivity Library.

Unfortunately, AutoCAD was not available in time for this review. I have therefore reviewed the book based on its ability to communicate the concepts and techniques for enhancing AutoCAD. I have focused on the section of the book called the Productivity Library. I cannot comment on the publisher-supplied and updated version of a disk that accompanies the book.

The tutorials cover hard disk management and DOS operations, macro writing, menu customization, and automating some drawing tasks. Detailed examples are appropriately used to illustrate the techniques described. The conversational tone is informal, and explanations are simple without being condescending.

The authors point out that because AutoCAD is a powerful but general-purpose design package, most users will require customization. Commands are provided for operations that some users might rarely use. The 20/80 rule is introduced here: Most users will end up using only about 20 percent of the commands about 80 percent of the time. Editing with Edlin is described in some detail on the grounds that it is bundled with MS-DOS. The authors lead the reader through the construction of a simple macro using Edlin.

Graphics Tablets

Shaefer and Brittain discuss the design of menus for graphics tablets. They assert that graphics tablets are the most efficient way to interact with AutoCAD and that the productivity gain more than offsets the expense of a tablet when compared with a mouse. The menu overlay on a graphics tablet can contain more choices than a screen menu, so you save time searching through menus for the desired command. With many commands spread out before you, solutions may suggest themselves that you might overlook if you had to search through a menu tree. The authors demonstrate how to apply ergonomic principles in designing a customized tablet menu for your applications.

The AutoCAD Productivity Book gives examples of design automation with AutoCAD, including a macro that automatically generates a parts list and another that automatically draws baseplates for steel light poles from engineers' specifications. You're encouraged to adapt these macros to your own needs.

The Productivity Library

The AutoCAD Productivity Library consists of a set of 70 macros and AutoLISP routines intended to be entered and run

continued

Illustration by Jennifer Skopp

"as is." An updated AutoCAD Productivity Diskette is available separately that relieves you of the task of manually entering the routines. It also contains routines that are not included in the book. While the authors offer some explanation for the AutoLISP routines, they make no attempt to teach LISP, for which you are appropriately referred to other sources.

The macros are documented with the standard pattern of the macro number and name, its purpose, step-by-step instructions for creating it, an example of its use, and guidelines for customizing the macro to your particular needs. Some of the macros are also used as examples in the tutorial section with more detailed explanation.

Most of the macros and AutoLISP routines are written for AutoCAD versions 2.15 through 2.5, while some are written specifically for version 2.5. Some of the others perform functions that have been added to version 2.5. No one will be able to use all of them, but everyone should find something to make working with AutoCAD easier.

The tools provided in the AutoCAD Productivity Library range from simple one-line macros to AutoLISP routines consisting of about a page of code. All macros are listed in both the table of contents and the index. A nice touch is the boldfacing of macro entries in the index.

The simpler macros merge frequently used sequences of AutoCAD commands into single menu selections. They do such things as erase the last entity created, check the spelling of text without having to specify attributes such as height and rotation, and move objects from one layer to another.

More complex macros are required to fit existing text into a specified area, create a parts list, or insert a sequence of numbers into a drawing. Other macros construct a square, rectangle, or parallelogram at arbitrary angles; draw ellipses and polygons automatically; and transfer text between drawings and ASCII files.

A Lever for Design Tasks

BYTE's April 1987 theme section on instruction set strategies explored the RISC (reduced instruction set computer) design approach. *The AutoCAD Productivity Book* redefines the RISC acronym to mean reduced instruction set command. The authors should have avoided obscuring the meaning of the term.

In my estimation, Shaefer and Brittain's book lives up to its subtitle, *Tapping the Hidden Power of AutoCAD*. The authors provide the necessary guidance to assist AutoCAD users at all levels of expertise to customize AutoCAD to better suit their needs.

In dealing with physical objects, a lever lets you multiply force to accomplish a task more easily, but you have to know where to place the lever to gain the maximum benefit. CAD is like a lever for design tasks, and *The AutoCAD Productivity Book* shows you where to place the AutoCAD lever to achieve the best results.

Editor's note: *A 100-page instructor's guide will be available in June for* The AutoCAD Productivity Book: Tapping the Hidden Power of AutoCAD, *coauthored by Charles Pietra and Jack Manno. It is designed for teachers conducting courses on customizing AutoCAD and includes a student workbook. The suggested retail price is $12.95.*

The guide is available from your local bookstore, or you can contact the publisher directly: Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515, (919) 490-0062.

Steven H. Rogers (P.O. Box 10967, Midwest City, OK 73140) is an engineering physicist who has worked with CAD technicians using the CALMA CAD system to design VLSI test structures.

continued

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THE WORLD OF PROGRAMMING LANGUAGES

Reviewed by Joel West

As an aficionado of programming languages, my eye was drawn to *The World of Programming Languages.* It's a compelling title that evokes an image of a professor telling a BASIC-hardened freshman of the wonders to unfold in his journey into computer languages.

Sure enough, this new book is derived from a previous college text with a somewhat drier title, *Programming Language Landscape: Syntax, Semantics and Implementation* (Chicago, IL: Science Research Associates Inc., College Division, 1986), also coauthored by Marcotty and Ledgard. Ledgard is the author of numerous books on Pascal and Ada and the editor of the Springer-Verlag series that includes that title. Michael Marcotty was a key player in defining PL/I, which, as the authors note, was the Ada of the late 1960s—a huge language designed by committee to be everything to everyone.

Previous Approaches to Language Design

The book surveys key areas of language design, such as abstractions and control structures. However, it's necessary to acknowledge the limitations of its scope. The authors focus on the evolution of procedural languages to 1981 or so, with particular emphasis on Algol, PL/I, Pascal, and Ada, but they virtually ignore LISP, Prolog, and the numerous object-oriented languages.

In fact, the book might be more accurately titled *The World of Procedural Languages: How to Design Ada.* As the preface notes, "The book has gained much of its breadth by the work done by Ledgard on the design of Ada."

The authors apply their decades of experience in such languages to a comprehensive survey of the previous approaches. Within the theme of procedural languages, they offer a thought-provoking analysis of the challenges facing the language designer, with specific alternatives for each choice along the way. The text is both well structured and eminently readable.

The first part briefly surveys the subject and defines the landscape. Part two discusses variables, control structures, data types, I/O procedures, and lexical scoping. The third part of the book covers type extensibility, dynamic data structures, exception handling, and separate compilation—key strengths of the Ada design. It also examines task synchronization, like that provided by Ada's rendezvous construct. However, the book skips the more experimental and powerful recent approaches to parallel processing. A copious bibliography supplied by the authors chronicles the historical steps along the way.

The Authors' Approach

Marcotty and Ledgard's approach to language design can be illustrated by an example from the "Control Structures" chapter. Suppose you wanted to design a construct similar to the Pascal CASE to select from multiple alternatives, as in

```
CASE character OF
  'A': Write('Vowel');
  'X': Write('Consonant');
  '0': Write('Digit');
END;
```

The text notes that one useful extension to this basic syntax is to allow an "otherwise" clause to be executed for a value that does not match one of the specified cases. But suppose the "otherwise" is omitted from a particular structure, and none of the cases match the value. Should this produce a run-time error? the authors ask.

continued

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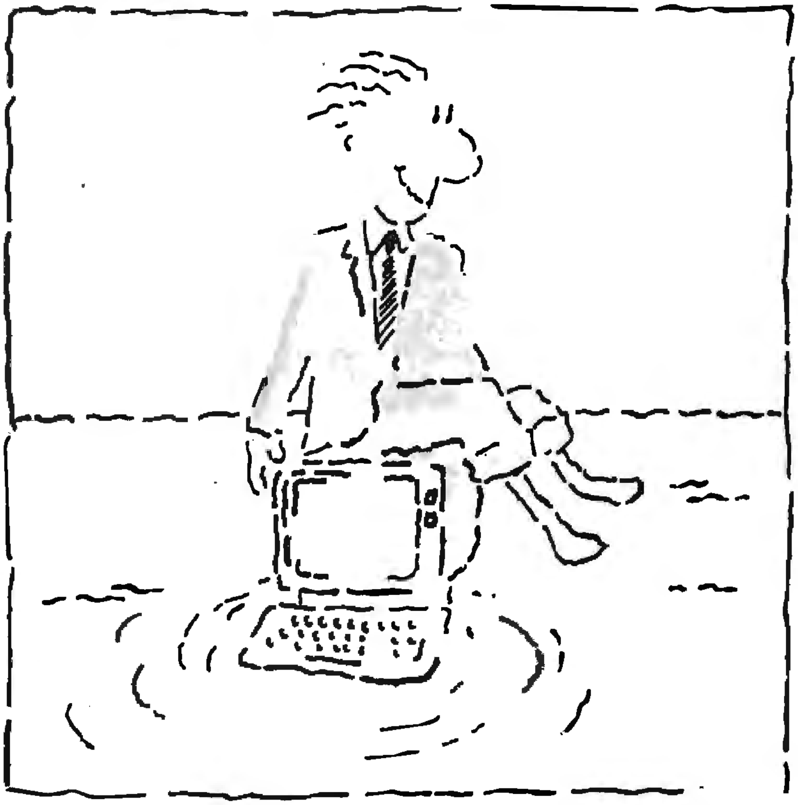

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Can the case conditions overlap? Is the order of case evaluation important? Answering such questions is the difference between a language defined by a written standard and a language defined only by its various (and possibly conflicting) implementations.

The Mini-Languages Approach

Each of the central chapters is developed around an imaginary simplified syntax for what Ledgard calls "mini-languages," which are stripped to the essentials to illustrate what he is discussing. This approach is at the core of the book's style and is perhaps its most problematic aspect.

These mini-languages let the authors tailor the syntax to just the problem being discussed. And where no existing language provides the necessary features, these languages let the authors focus the discussion on the topic at hand. They also give them a chance to design more languages in one book than many design in a lifetime, without the messiness of actual implementation.

However, many (if not most) of the languages resemble Ada, with a sprinkling of Pascal and PL/I thrown in. For example, the control structures exactly mimic the Ada approach, even where the approach of, say, Pascal provides the identical capabilities with an equally valid syntax.

More significantly, the approach is unnecessarily abstract, particularly when the Ada model is so closely followed. For the most part, each chapter would require only a few small syntax changes and an indication of the language illustrated to make the prose more concrete. In a book that is intended for the professional, an analysis of language design through case studies for each chapter would be more relevant and easier to follow. It would also allow the authors to spend more time acquainting the readers with the characteristics of the key languages, an important benefit for a survey text from such experienced hands.

Significant Omissions

Within its focus on procedural languages, this book's coverage of C seems particularly thin. The discussion of I/O abstractions, for example, somehow ignores one of the most flexible of such facilities available today. Meanwhile, the authors cover PL/I in some detail, despite the fact that the language is, like Ada, at the end of an evolutionary path, rather than the forebear of later languages, as with Algol, Pascal, and Smalltalk.

References to 72-column punched cards are amusing anachronisms that date the authors. However, the dismissal of the IEEE standard for floating point is a significant omission. With its treatment of infinities and imprecise results, IEEE-754 is an important reality of modern microsystems, defined by hardware such as the Intel 80x87 series and software such as the Standard Apple Numeric Environment (SANE).

Keep It Simple

The authors save their best for last. The final chapter, "The Swamp of Complexity," offers a revealing discussion from battle-scarred veterans that is all too brief.

As its title suggests, the chapter outlines how the excesses of language designers hinder the usability of their end result by making a language impracticably complex. The designer may be tempted to keep adding more and more, but the overriding goal should be to simplify and unify the language into a coherent whole. This message is clearly applicable to the design of any programming language.

The tendency toward complexity grows out of hand as the goals of the language become unfocused and the designer attempts to offer all things to all people. The problem is made even worse by the process of design by committee. To quote the authors:

continued

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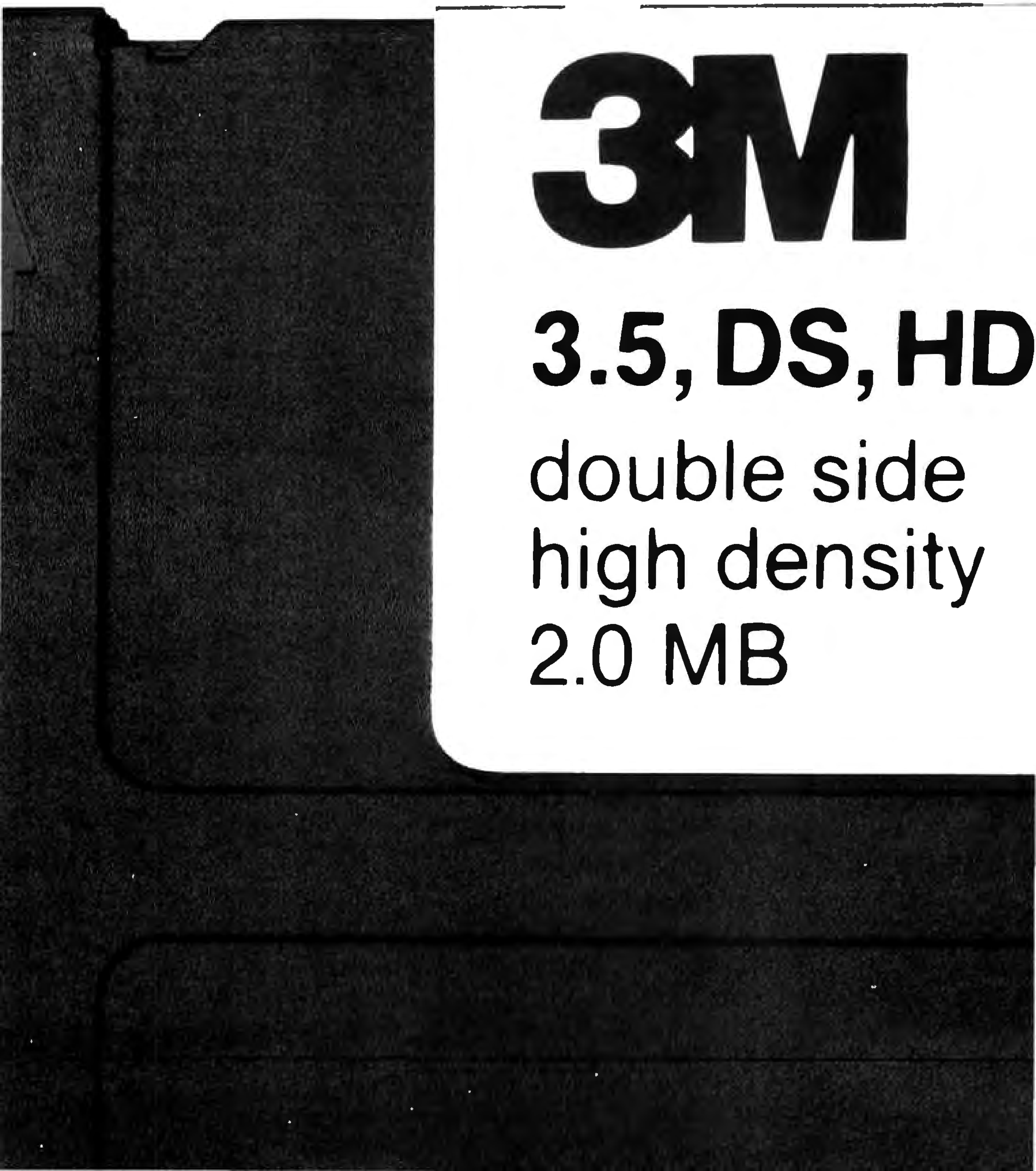

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Inquiry 3

> In both PL/I and Ada, the size and complexity of the languages go to the limits of the user's intellectual control. These languages, which were designed by what amounts to very large committees, may be compared to languages that were designed by individuals or small committees, for example Algol 60, Algol 68, Pascal, and APL. Although they may have other problems, they do not suffer to the same degree from complexity due to absolute size.

Marcotty and Ledgard admonish the designer to build around a minimum of concepts and a readable syntax. And, as is now axiomatic, a language with extensible data types (such as Modula-2) can be much simpler yet more powerful than one in which all types are predefined, such as PL/I.

This concluding chapter presents the overall view of language design that naturally follows from the detailed analysis that preceded it. For newcomers, it is the fitting culmination of an introductory tour, while the more experienced will find it a hidden chestnut at the end of the trip through the familiar territory of programming languages.

Joel West (P.O. Box 2733, Vista, CA 92083) is a writer, programmer, and consultant who dabbles in language design.

THE INGRES PAPERS: ANATOMY OF A RELATIONAL DATABASE SYSTEM

Reviewed by Haim Kilov

It's hard to find a large commercial database management system whose authors can frankly assess their design and development decisions. INGRES is such a DBMS, and *The INGRES Papers* is a collection of 22 papers selected and edited by its founding father, Michael Stonebraker. The papers are reprinted from various journals and conference proceedings, and two of them seem to have been written especially for this book.

Stonebraker's short introductions both to the book and to each of its six sections provide an interesting and instructive view on corresponding aspects of the system. The reader should note that INGRES is a living and developing organism; new papers on further developments continue to appear.

The papers included in this collection address various theoretical and practical aspects of the design and development of a large relational DBMS. They are usually very well written; the authors never present the material as highbrow mathematics, though the papers do use and at times create theoretically important results. The reader should have a basic knowledge of relational DBMSs, and a certain computing maturity is also desirable.

Technical Superiority

The book includes three papers on the evolution of INGRES from a University of California at Berkeley prototype to a famous commercial system (Stonebraker was one of the creators of Relational Technology Inc., a company in Alameda, California, that has turned INGRES into a product). Not having the support of a large established company, the developers had to base the success of their product on technical superiority.

It is interesting to note that the INGRES project has always been organized as a chief programmer team. All members of these teams—except the chief programmers—were students, and all of them, as well as the chief programmers, are listed in the editor's preface. There are some famous names in the list.

continued

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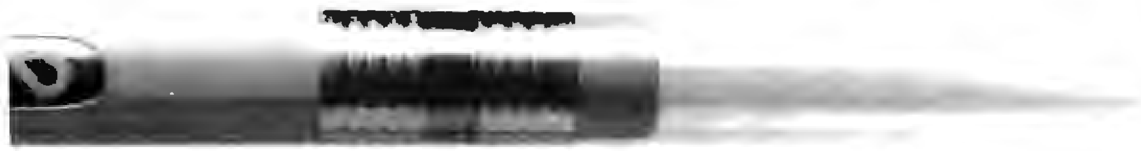

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Unlike papers on other commercial systems, *The INGRES Papers* discuss at length not only successes but failures and demonstrate lessons learned during the development of the system. Because the authors' approach is always open and sincere, it is clear that their goal was to create a powerful but simple and usable (rather than deliberately complex) system. They have succeeded.

The reader should take into account that INGRES is a full-function relational database management system rather than a flat-file system or a relational interface to a navigational system, too many of which are now proudly proclaimed as "relational." I agree with the authors' note: "We overestimated the ability of others to build relational systems and bring them to market."

Reevaluating Steps

One whole section discusses traditional aspects of DBMS design and implementation. Of interest here is the observation that the services of a very good general-purpose operating system (Unix) are often inadequate. Instead of their "not quite right" service to a comparable applications-specific one, a "mini-OS" runs in user space.

On a higher level, the authors provide convincing evidence that some common beliefs concerning DBMS performance enhancements were just wrong. On a still higher level, it can be seen that query-processing algorithms, however important, are not the main aspect of a relational DBMS. In particular, the corresponding algorithms in "university INGRES" had some drawbacks, but even the systems based on these algorithms were successful (the current commercial INGRES uses a rewritten query optimizer).

The distributed INGRES is discussed in full. Though it is a very interesting project that more or less works, its success was limited by software engineering issues: It was impossible to succeed simultaneously in three areas—application code (distributed INGRES itself), OS code (networking), and obtaining prototype (Ethernet) hardware. As the authors correctly note, smaller steps were needed.

Historical Interfacing

The story of user interfaces ranging from traditional embedding of the relational data sublanguage (QUEL), into a general-purpose programming language (C), and up to more recent and very interesting developments is told. As "it was clear to everyone that ordinary mortals did not want to use QUEL for data manipulation," more convenient means were designed and implemented.

One of the best interfaces was designed through the use of forms—taking into account that a typical database-oriented program is at least 60 percent composed of code to manipulate the screen. In many user interface aspects, the designers of INGRES have done a pioneering job unusual for the development of a commercial system.

Another important example brought forth in the book is RIGEL, a general-purpose language designed for developing database applications; note that the paper corresponding to that topic was published in 1979. RIGEL provides the (Modula-2-like) module facility for definition and use of high-level abstract database operations (like `AssignProf` and `AddStudent`) instead of low-level ones (e.g., `insert`, `delete`, and `update`). These high-level operations enforce the semantic integrity in a very natural manner.

Also of interest and importance is the wide use of generators in RIGEL. These aspects provide a good, but not the only, example of DBMS design as a fruitful field for integrating different important computing concepts.

continued

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New-Generation Applications
Nontraditional database applications are also considered at length. Stonebraker notes that corresponding extensions to the relational model should be of "great power at very small cost in intellectual complexity," an admirable goal. Some great discoveries in computing (like the relational model itself) can be characterized in such a manner. It is well known that the problem with older, and even some newer, database systems is excessive complexity.

The authors show paths to new-generation DBMSs and implement them by extending an existing commercial system. Of special merit are the use of abstract data types for domains and extending the DBMS with long free-format text document processing facilities. Work in these areas is flourishing in the database community, and the decisions made and implemented by INGRES's authors are both simple and elegant.

New Designs
The issue of assuring semantic integrity through the use of P. Chen's entity-relationship (ER) model in database design and with interesting ways of access path design is a large part of this last section. A semantically correct database schema can be designed at once in a simple top-down manner if we use the ER concepts instead of creating first a more or less arbitrary collection of relations and then normalizing them.

Formal normalization is not a very natural process; it's like writing a structured program by formally and syntactically eliminating goto from an unstructured one. In both cases, a program and a schema should be semantically correct from the beginning; in both cases the creation of a correct object is much simpler. The interested reader can read the variety of papers on normalization and normal forms that seem to have had little impact on actual database design. A new normal form, to quote Stonebraker, is the thing least needed by a database community.

A Coherent Whole
Each of the papers except one was coauthored by the INGRES project leaders. As a result, the papers have some overlap, but they do constitute a coherent whole. The reader should be cautious with respect to papers published in 1975 and 1976, as they contain "naive comments" carefully noted by Stonebraker in his section introductions. Not noted in such a manner is the use of the term "domain" instead of "attribute" in several of these papers. These two terms should be clearly distinguished; they are used properly only in papers published in 1981 and later. I disagree with the statement that existing systems do not support sophisticated domain definition; at least one system that I coauthored does this support, at least partially (see *SIGMOD Record*, volume 13 , number 2, 1983, page 64).

The INGRES Papers presents important and diverse aspects of DBMS design and development, including software engineering issues connected with a large project. The authors sincerely present the lessons they learned. Their experience will be useful not only for DBMS designers and sophisticated users, but also for large project developers. The book can best be used as supplementary reading in a DBMS course.

For readers of BYTE who too often encounter claims of a DBMS being relational and who are really interested in databases, this well-written book offers a splendid opportunity to get acquainted with various aspects of a full-function relational DBMS on its way to being a new-generation one. ■

Haim Kilov (Karl Marx St. 75-13, Riga 11, U.S.S.R.) is involved in both the design and implementation of relational database management systems and computer science education. His papers and reviews have been published in the U.S.S.R. and in the U.S.

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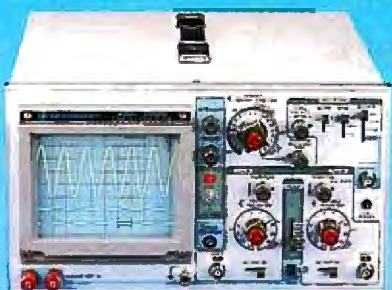

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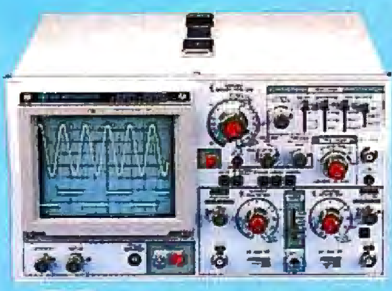

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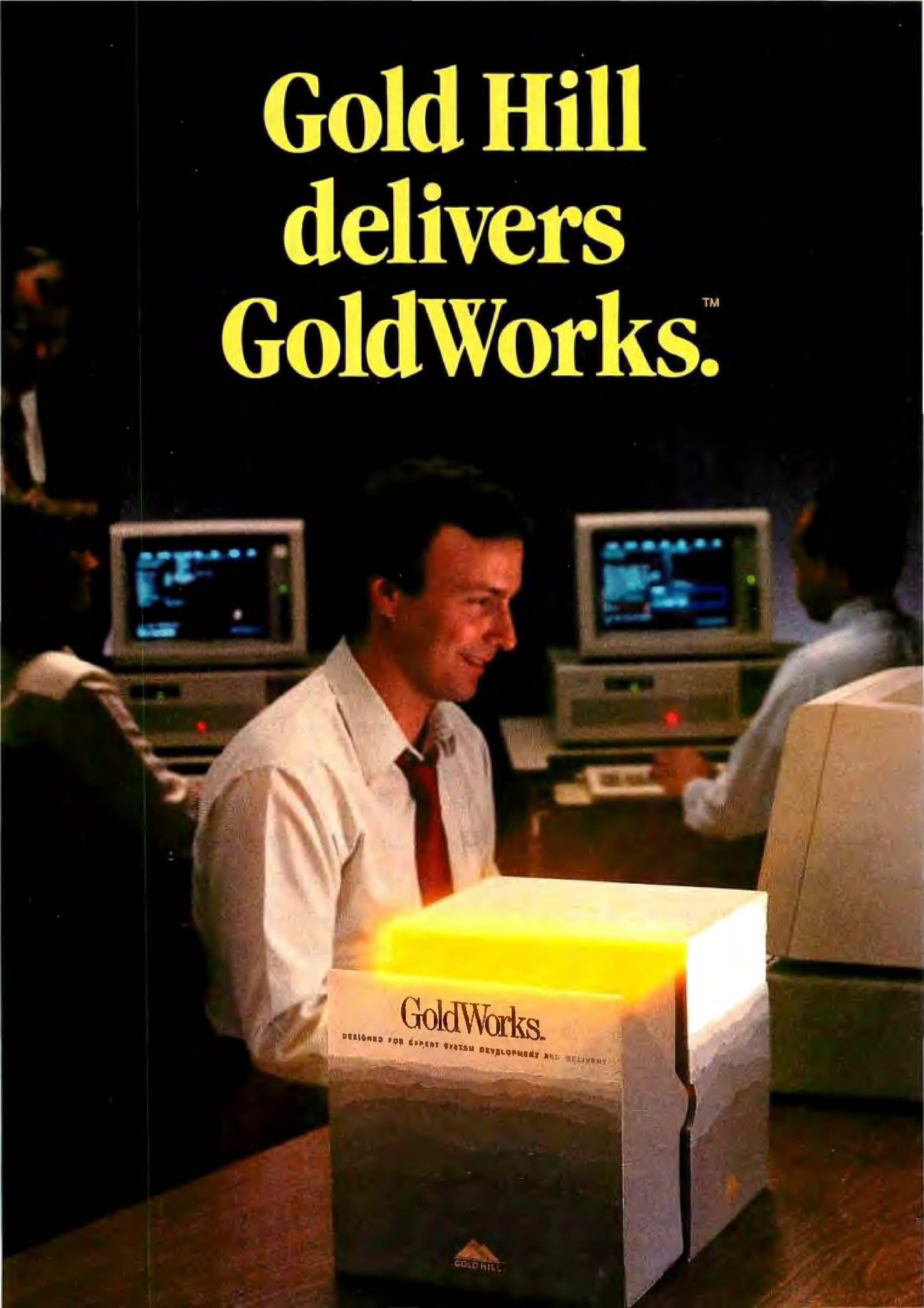
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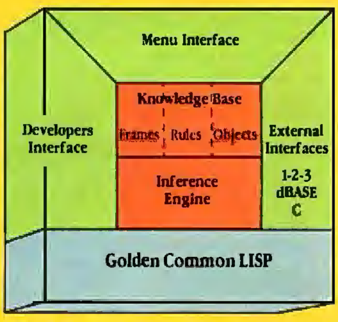

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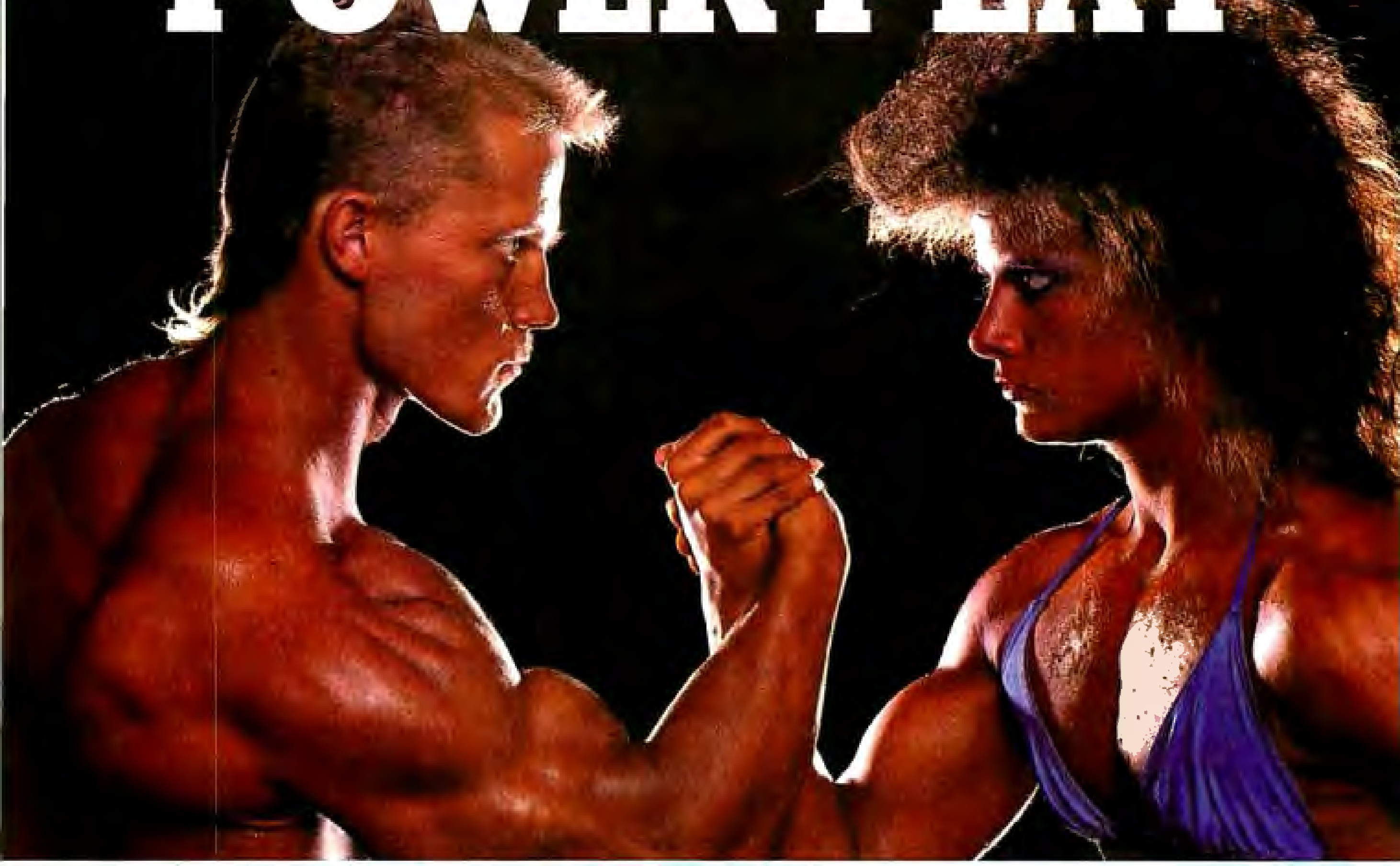

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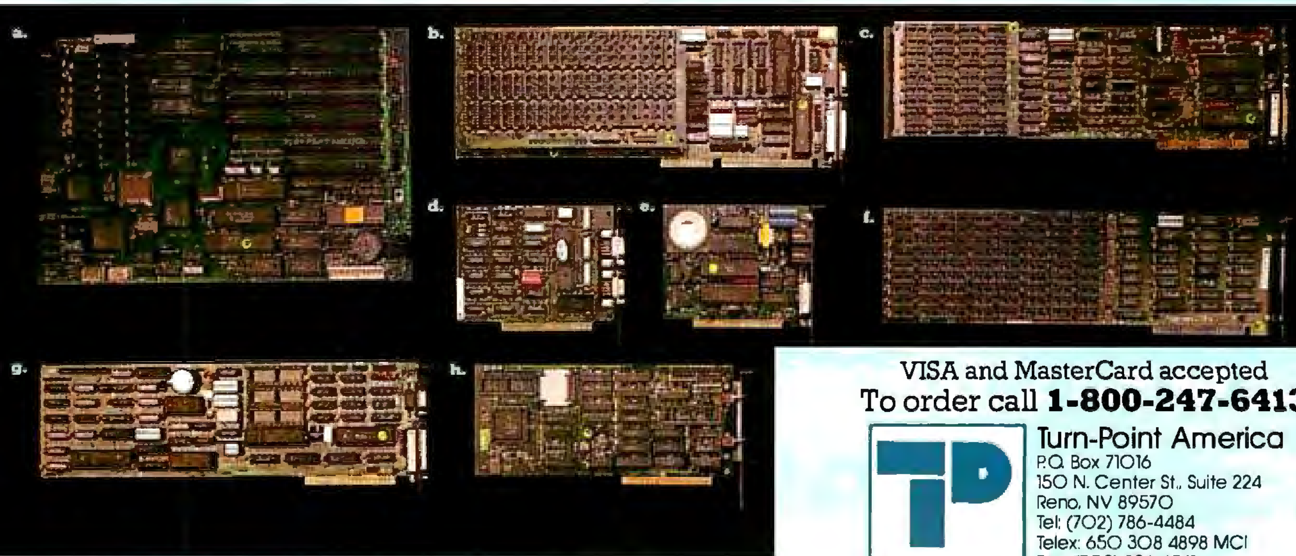

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IBM's Personal System/2 family includes a low-end 8086-based machine, two mid-range 80286 systems, and a 32-bit 80386-based system that is arguably one of the most powerful microcomputers yet. (See table 1.)

Unlike the previous line of IBM desktop PCs, all the new systems have: 3½-inch floppy disk drives (not a 5¼-inch floppy in the group, though you can add one externally), on-board graphics support, heavy use of custom logic chips and surface-mount technology, and a simple, modular assembly technique. IBM claims that, because of the modular construction, the new computers are three times more reliable than the previous IBM desktop machines. Service, when needed, will be simpler: with practice, you can assemble or disassemble the PS/2 machines in less than a minute.

Principal contributors to this article include (alphabetically) Richard Grehan, Philip Lemmons, Rich Malloy, Tom Thompson, Eva White, Gregg Williams, and Stanley Wszola. All are BYTE staff members.

The PS/2 systems feature colorful analog video displays and a keyboard that resembles the "enhanced" AT keyboard, except for three LED indicators for the three Shift-Lock keys. They can also use an optional two-button mouse ($95), the first mouse ever offered by IBM.

Contrary to rumor, all the systems use off-the-shelf Intel microprocessors and do not appear to employ any extraordinary measures to dissuade imitators—although the complex custom gate arrays will give clone makers pause. IBM also will not publish the PS/2 BIOS listing or the circuit diagrams and electrical characteristics of the new gate arrays, but it will publish the entry points of the BIOS and the electrical signals on the new expansion slots.

Basic Hardware: The Model 30

The Personal System/2 Model 30 uses an 8086 microprocessor running at 8 MHz with no wait states. It comes with 640K bytes of memory and two 3½-inch floppy disk drives that store 720K bytes each. It also has three standard IBM PC-style expansion slots, which are mounted sideways in the machine to conserve space. Much of the circuitry formerly provided by expansion boards now resides on the motherboard: an improved version of the IBM Color Graphics Adapter (CGA), serial and parallel ports, a clock/calendar, and a floppy disk drive controller.

Because of the higher clock speed, a 16-bit-wide data path, and new support chips around the 8086, IBM says the Model 30 can perform at up to 2½ times the speed of a PC XT.

A two-floppy Model 30 costs $1695; a version with a single floppy drive and a 20-megabyte hard disk costs $2295. All you need to complete a Model 30 system are a monitor ($250 to $685) and version 3.3 of DOS ($120).

Models 50, 60, and 80

The group of higher-end machines consists of the 80286-based Models 50 and 60 and the 80386-based Model 80. They have all the features of the Model 30, with three major differences: They use a proprietary bus called the Micro Channel, they have on-board support for a new graphics standard that is better than the Enhanced Graphics Adapter (EGA); and they use 1.44-megabyte floppy disk drives that can also read and write to the 720K byte floppies.

These systems also use a high-speed hard disk controller, with a 1:1 interleave factor (AT-class hard drives usually use a 3:1 interleave). This interleave factor is made possible in part by a "burst" mode in the bus that allows high-speed data transfers. Models 60 and 80 also have an ESDI (enhanced small device interface) adapter available for high-speed data transfer to a hard disk. With these features Models 60 and 80 have six times the data-transfer rate of the AT.

Models 50 and 60 are essentially the same machine; they differ primarily in size and storage capacity. Both use an 80286 running at 10 MHz and can support an optional 10-MHz 80287. Both computers come with a megabyte of memory and a 16-bit version of the Micro

continued

The IBM Personal System/2 Computers.
From left to right, the Models 80, 50, 30, 60.

Photographs by Paul Avis

Channel bus. The Model 50, however, is a small-footprint desktop system with three open expansion slots, while the Model 60 is a larger, floor-standing "deskside" system with seven available expansion slots.

The Model 50 comes with a 20-megabyte hard disk and costs $3595. The Model 60 is available in two versions: The Model 60-041 has a 44-megabyte drive and costs $5295; the Model 60-071 includes a 70-megabyte hard disk and an ESDI for $6295.

IBM estimates that with the faster clock speed, the new bus, and the faster drive controller, these systems will perform at over twice the speed of the AT.

The Model 80 is IBM's first 80386-based system. It uses a standard Intel B1-version 80386 CPU chip—the same chip used in the Compaq Deskpro 386. The Model 80, which will be available in July, comes with 1 to 2 megabytes of memory (using 1-megabit chips) and a 32-bit version of the Micro Channel bus. It is a deskside system that resembles the Model 60 and, like the 60, it has seven expansion slots, three of which are for 32-bit boards. The Model 80-041 has a 44-megabyte hard disk and will sell for a base price of $6995. The 80-071 has a 70-megabyte hard disk and a base price of $8495. Both of these systems have a clock speed of 16 MHz. The third version of the Model 80, the 80-111, will have a clock speed of 20 MHz, 2 megabytes of memory, and a 115-megabyte hard disk. It will be available in the fourth quarter of this year for $10,995. IBM estimates the performance of the Model 80 to be about 3½ times that of an AT.

The Model 80 will compete with Apple's powerful 32-bit Mac II, at least on the hardware level. However, the Mac II's system software is already in place and available; OS/2, the major new operating system for the PS/2 family, might still be as much as a year away from release. See the text box "IBM PS/2 Model 80 vs. Mac II," which highlights some of the similarities and differences between the two machines.

New Video Standards

The PS/2 family uses three new video standards: the low-end Model 30 has an MCGA (multicolor graphics array) system; the Models 50, 60, and 80 have a VGA (video graphics array) system; and there is an optional high-resolution system called the 8514/A.

Model 30's MCGA system consists of two special gate arrays, 64K bytes of dual-ported RAM, a 16K-byte static RAM character generator, and custom

continued

The Model 80—IBM's first 80386-based system—will compete head-to-head with Apple's powerful 32-bit Macintosh II.

MODEL 80

Table 1: *A summary of the characteristics of the IBM Personal System/2 computers, Models 30, 50, 60, and 80.*

Model (notes 1,2)	**Model 30-021** (8530-021)	**Model 50-021** (8550-021)	**Model 60-041** (8560-041)	**Model 80-041** (8580-041)	**Model 80-111** (8580-111)
Microprocessor	8086	80286	80286	80386	80386
Processor speed	8 MHz	10 MHz	10 MHz	16 MHz	20 MHz
Socket for which numeric coprocessor?	8087	80287	80287	80387	80387
Width of system-bus data path	16 bits	16 bits	16 bits	32 bits (note 12)	32 bits (note 12)
Standard RAM	640K bytes	1 megabyte	1 megabyte	1 megabyte (note 9)	2 megabytes
Maximum RAM	640K bytes (note 3)	7 megabytes	15 megabytes	16 megabytes	16 megabytes
Standard ROM	64K bytes	128K bytes	128K bytes	128K bytes	128K bytes
Total number of slots	3	4 (note 5)	8 (note 5)	8 (note 5)	8 (note 5)
Type of slots	IBM PC	Micro Channel	Micro Channel	Micro Channel	Micro Channel
Operating system(s) available	DOS 3.3	DOS 3.3, OS/2	DOS 3.3, OS/2	DOS 3.3, OS/2	DOS 3.3, OS/2
Standard floppy disk size and capacity	3½-inch, 720K (note 4)	3½-inch, 1.44 megabytes (note 6)	3½-inch, 1.44 megabytes (note 7)	3½-inch, 1.44 megabytes (note 7)	3½-inch, 1.44 megabytes (note 7)
Hard disk supplied	20 megabytes	20 megabytes	44 megabytes (notes 8 and 10)	44 megabytes (note 9)	115 megabytes (note 13)
Maximum hard disk capacity	(note 4)	20 megabytes	88 megabytes (note 11)	88 megabytes (note 10)	230 megabytes
Standard graphics modes	MCGA	VGA, EGA, MCGA	VGA, EGA, MCGA	VGA, EGA, MCGA	VGA, EGA, MCGA
Able to use 1024 by 768 IBM 8514 Color Display?	no	yes, with optional board using 1 slot	yes, with optional board using 1 slot	yes, with optional board using 1 slot	yes, with optional board using 1 slot
Location of main system unit	on desk	on desk	on floor, standing vertically	on floor, standing vertically	on floor, standing vertically
System price (note 14)	$2295	$3595	$5295 (note 8)	$6995 (note 9)	$10,995
Availability	now	now	now	July 1987	4th quarter 1987
Major improvements over model to the left	N/A	80286, more memory, VGA, Micro Channel slots	more slots, more memory	80386, 32-bit slots	20-MHz clock, more RAM on motherboard

1. For details of the graphics modes, see the main text.
2. All the computers have their video circuitry, serial port, parallel port, pointing-device port, and time-of-day clock on the motherboard. They connect to an analog RGB or monochrome monitor. A two-button mouse is available but not required. All computers can interface to an IBM 200-megabyte optical disk drive (external for Models 30 and 50, internal or external for Models 60 and 80).
3. You can expand memory further by using plug-in boards that meet the Lotus/Microsoft/Intel memory-board specification.
4. Another version of the Model 30, the Model 30-002, has a second 3½-inch floppy disk drive in place of the 20-megabyte hard disk; it costs $1695. Presumably, the Model 30 can use any hard disk that attaches to the computer via an IBM PC plug-in board.
5. The hard disk interface board occupies one of these slots.
6. The Model 50 contains space for another internal 3½-inch, 1.44-megabyte floppy disk drive.
7. This computer has room for another internal 3½-inch, 1.44-megabyte floppy disk drive and for a second internal hard drive or optical disk drive.
8. The Model 60 comes in a second model, Model 60-071, that is identical to the 60-041 except for its hard disk size, which is 70 megabytes; its price is $6295.
9. The 16-MHz Model 80 also comes in a second model, the Model 80-071, that is identical except for its hard disk size, which is 70 megabytes, and a total of 2 megabytes of RAM; its price is $8295.
10. The -071 model's 70-megabyte drive uses an ESDI disk interface running at 10 megabits per second, which is twice as fast as the ST 506 interface used on the 44-megabyte drive.
11. The Model 60-071 can have a maximum of 185 megabytes of hard disk storage.
12. All Model 80s have 8 slots, 3 of which can support either 16- or 32-bit boards. One 16-bit slot is used by the hard disk.
13. Both the standard and the optional hard disk on the Model 80-111 use the ESDI disk interface and are driven at 10 megabits per second.
14. Prices do not include operating system(s) chosen by user ($120-$795) or manuals ($45-$125 each).

IBM PS/2 Model 80 vs. Mac II

How does the price of IBM's new 32-bit machine compare with Apple's recently introduced 32-bit Macintosh II? At first glance, the prices look pretty even, but look closely at the standard equipment:

IBM's PS/2 Model 80-041	**Apple's Mac II** Model HD40
16-MHz 80386	16-MHz 68020
1 megabyte of RAM	1 megabyte of RAM
1.44-megabyte floppy	800K-byte floppy
44-megabyte hard disk	40-megabyte hard disk
3 open 32-bit slots	5 open 32-bit slots
4 open 16-bit slots	
keyboard	keyboard
video card	video card
	68881 coprocessor
	system software
	13-inch color monitor
Price: $6995	**Price:** $6996

To get a PS/2 that has features comparable to what comes standard with the high-end color Mac II, you'd have to add these options: an 80387 math coprocessor ($795); a 12-inch color monitor ($685); and the OS/2 operating system ($325), which doesn't yet have graphics and windowing. Tack the costs of the options onto the cost of the Model 80 and the price tag reads more like $8800, making the Mac II about $1800 less expensive. You'd have more than enough left over to buy AST Research's Mac286 board ($1499), which lets the Mac run MS-DOS programs.

The 8514 color monitor provides resolution up to 1024 by 768 pixels.

circuitry that implements a 256- by 18-bit color palette.

The system supports several modes: 80-column text (with 640- by 400-pixel total resolution, 8- by 16-character box, 16 of 256K colors), 320 by 200 graphics (with 256 of256K colors, 8- by 8-character box), 640 by 200 graphics (with 2 of 256K colors, 8- by 8-character box), and 640 by 480 graphics (with 2 of 256K colors, 8- by 16-character box). An optional board lets the system boost the text mode resolution to 720 horizontal pixels and allow a 9- by 16-character box.

In each mode, you can use any of 262,144 possible colors. Although the resolution in the 320 by 200 graphics mode is low, the large number of colors available on the screen at one time (256) and the large number of possible colors (262,144) gives the system the ability to produce some striking graphic images.

The MCGA can emulate the old CGA graphics for programs that use it, but cannot emulate EGA graphics without a special adapter card.

The VGA system is standard on Models 50, 60, and 80, and optional on Model 30. VGA is based on one gate array containing 12,750 gates. In addition to the modes supported by the MCGA, the VGA supports the EGA graphics standard and the following additional modes: text (720 by 400 total resolution, 9- by 16-character matrix) and 640 by 480 graphics (16 of 256 colors). The VGA arbitrates between the video memory and the processor, and the video memory and display circuitry.

The optional 8514/A graphics adapter uses the systems' *auxiliary video connector*, a 20-pin connector in line with one of the 16-bit Micro Channel slots. A video card plugged into this slot can substitute its own pixel and/or timing signals for those on the motherboard, providing a way to produce different kinds of video displays without replacing the video circuitry on the motherboard. In this way, the 8514/A supports a high-resolution mode of 1024 by 768 pixels on one of IBM's new monitors, the 8514. With an optional memory-expansion card, it can display 256 colors out of a possible 262,144 at this resolution. At a lower resolution (640 by 480), the 8514/A adapter can provide additional capabilities such as programmable character fonts, proportional spacing, and patterned area fills. The 8514/A costs $1290.

Analog Monitors

Both the MCGA and the VGA systems can work with any of four new analog monitors: a medium-resolution monochrome monitor, two medium-resolution

continued


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color monitors, and a large, high resolution color monitor. Each monitor has a horizontal refresh rate of 31.75 KHz and a vertical refresh rate of either 50 or 70 Hz. Total bandwidth is up to 70 MHz.

The Model 8503 monochrome monitor measures 12 inches diagonally and costs $250. It uses IBM's version of a paper-white phosphor and shows no flicker or unsteadiness. Both the MCGA and the VGA can automatically detect the presence of this monitor and generate a monochrome image by using the 6-bit green component of the video signal to get 64 shades of gray.

The 8512 color monitor measures 14 inches diagonally and costs $595. The 8513 is similar to the 8512 but is slightly smaller (12 inches) and has a finer dot pitch (0.28 mm); it costs $685.

The 8514 is a 16-inch color display that is compatible with the 640-by-480 mode of the VGA and MCGA, and can accommodate the 8514/A video system's 1024-by-768 resolution. It costs $1550.

All of the monitors except the high-resolution 8514 are available now; the 8514 will be available in July.

The Model 30 is up to 2½ times as fast as an XT.

BIOS Compatibility

The biggest news about the BIOS (basic input/output system) contained in the ROM of all the PS/2 computers is that it is almost entirely entry-point-compatible with the old BIOS. This means that any software that accesses system functions by calling BIOS routines (e.g., using the disk, changing the video display) will work on the new PS/2 machines.

The PS/2 Model 30 is compatible at the BIOS level with the older IBM PC, PC XT, Portable PC, and PC Convertible and with most hardware interfaces. It is designed to maintain compatibility with as much software developed for the PC as possible. Unfortunately, code that depends on a set execution time will not run correctly because the Model 30 runs faster than the PCs (8 MHz versus 4.77 MHz).

The PS/2 Models 50, 60, and 80 have a superset of the standard PC BIOS. The compatibility BIOS (or CBIOS) can address up to 1 megabyte of memory; it lets you run most of the currently available software. The Advanced BIOS (or ABIOS) provides support for multitasking operations and can address up to 16 megabytes of memory.

The BIOS on the Model 30 resides in two 27256 ROMs. The BIOS for the Models 50 and 60 is contained in a set of four 27256 ROMs and takes 128K bytes. As with previous models of IBM computers, each BIOS ROM module has a model identification byte located at FOOO:FFFE hexadecimal.

IBM has changed some of the BIOS interrupts, but the changes make little practical difference. For example, interrupts 0B and 0C hexadecimal (communications), 0D (alternate printer), and 0F (printer) are now reserved. Interrupt 15 hexadecimal, which was the Cassette I/O System Extensions, has been relabeled System Services, though it still performs the same functions. Interrupts 40, 41, 46, and 4A hexadecimal were reserved, but now control Diskette BIOS Revector, Fixed Disk Parameters, and User Alarm respectively. Interrupts 71 through 74, 76, and 77 hexadecimal are now reserved; they had been IRQ 9 through 12, 14, and 15 (decimal). And interrupts F1 through FF hexadecimal, previously not used, are now reserved for User Program Interrupts.

To the average user running most IBM software, these changes to the BIOS will be invisible. Some non-IBM programs will need extensive rewriting, however. A good example of the extent to which IBM has maintained compatibility with the previous PCs: the ROM chips also contain Cassette BASIC Version C1.10.

MODEL 30

Micro Channel: The New Bus

The Micro Channel bus is neither electrically nor mechanically compatible with the old IBM PC bus. The trade-off for the lack of compatibility is that the new design is capable of high-speed data and I/O transfers, sharing resources, and multiprocessing support. The Models 50 and 60 use a 16-bit-wide variant of the bus, while the Model 80 supports a full 32-bit-wide data path on 3 of its 8 slots. (However, at press time, we had not yet received full documentation on the 32-bit version.)

The Micro Channel is worth examining in some detail: Basically, it's a non-multiplexed bus (i.e., data and addresses have their own separate lines) that has additional lines for transfer control, arbitration, support signals, and power. All logic signal lines on the channel are TTL-compatible. The channel slots are dual-pin card-edge connectors that accept 11½- by 3-inch peripheral cards. (See figure 1.)

The bus, and indeed the entire system architecture, shows attention to detail in reducing electromagnetic interference: every fourth pin on one side of each slot has a ground line, and the motherboard and all the cards have ground planes. The designers said they think such an architecture is effective for reducing interference, not only for current machines but

continued

Rear of the System Board

B	Pin	A
AUDIO GND	01	-CD SETUP
AUDIO	02	MADE 24
GND	03	GND
14.3 MHz OSC	04	A 11
GND	05	A 10
A 23	06	A 09
A 22	07	+5 Vdc
A 21	08	A 08
GND	09	A 07
A 20	10	A 06
A 19	11	+5 Vdc
A 18	12	A 05
GND	13	A 04
A 17	14	A 03
A 16	15	+5 Vdc
A 15	16	A 02
GND	17	A 01
A 14	18	A 00
A 13	19	+12 Vdc
A 12	20	-ADL
GND	21	-PREEMPT
-IRQ 09	22	-BURST
-IRQ 03	23	−12 Vdc
-IRQ 04	24	ARB 00
GND	25	ARB 01
-IRQ 05	26	ARB 02
-IRQ 06	27	−12 Vdc
-IRQ 07	28	ARB 03
GND	29	ARB/-GNT
Reserved	30	-TC
Reserved	31	+5 Vdc
-CHCK	32	-S0
GND	33	-S1
-CMD	34	M/-IO
CHRDYRTN	35	+12 Vdc
-CD SFDBK	36	CD CHRDY
GND	37	D 00
D 01	38	D 02
D 03	39	+5 Vdc
D 04	40	D 05
GND	41	D 06
CHRESET	42	D 07
Reserved	43	GND
Reserved	44	-DS 16 RTN
GND	45	-REFRESH
KEY	46	KEY
KEY	47	KEY
D 08	48	+5 Vdc
D 09	49	D 10
GND	50	D 11
D 12	51	D 13
D 14	52	+12 Vdc
D 15	53	Reserved
GND	54	-SBHE
-IRQ 10	55	-CD DS 16
-IRQ 11	56	+5 Vdc
-IRQ 12	57	-IRQ 14
GND	58	-IRQ 15

Key

Abbreviation	Full Line Name
A0 to A23	Address Bits 0 to 23
D0 to D15	Data Bits 0 to 15
-ADL	-Address Decode Latch
-CD DS 16(n)	-Card Data Size 16 (note 1; indicates 16-bit data on bus)
-DS 16 RTN	-Data Size 16 Return
-SBHE	-System Byte High Enable
MADE 24	Memory Address Enable 24 (active if current address is in the first 16 megabytes of the address space)
M/-IO	Memory/-Input/Output (distinguishes memory from I/O cycle)
-S0, -S1	Status Bits 0 and 1 (define the type of bus cycle)
-CMD	-Command (denotes valid data on data bus)
-CD SFDBK(n)	-Card Selected Feedback (note 1)
CD CHRDY(n)	Channel Ready (note 1)
CHRDYRTN	Channel Ready Return
ARB0 to ARB3	Arbitration Bus 0 to 3
ARB/-GNT	Arbitrate/-Grant (used in arbitrating access to bus)
-PREEMPT	-Preempt (used to request use of the bus)
-BURST	-Burst (used to signal extended use of bus in burst mode)
-TC	-Terminal Count
-IRQ3 to 7, 9 to 12, 14, 15	-Interrupt Request Lines (used to signal I/O slave's need for servicing)
-CD SETUP(n)	-Card Setup (note 1)
-CHCK	-Channel Check (indicates serious system error)
AUDIO	Audio Sum Node
AUDIO GND	Audio Ground
OSC	Oscillator (14.31818 MHz)
CHRESET	Channel Reset
-REFRESH	-Refresh

1. These are separate, dedicated lines running to each slot.

Figure 1: *The Micro Channel slot pin-outs.*

MODEL 50

for future systems as well. And in fact, all of the PS/2 systems have FCC Class B certification despite the fact that they are running at high clock speeds.

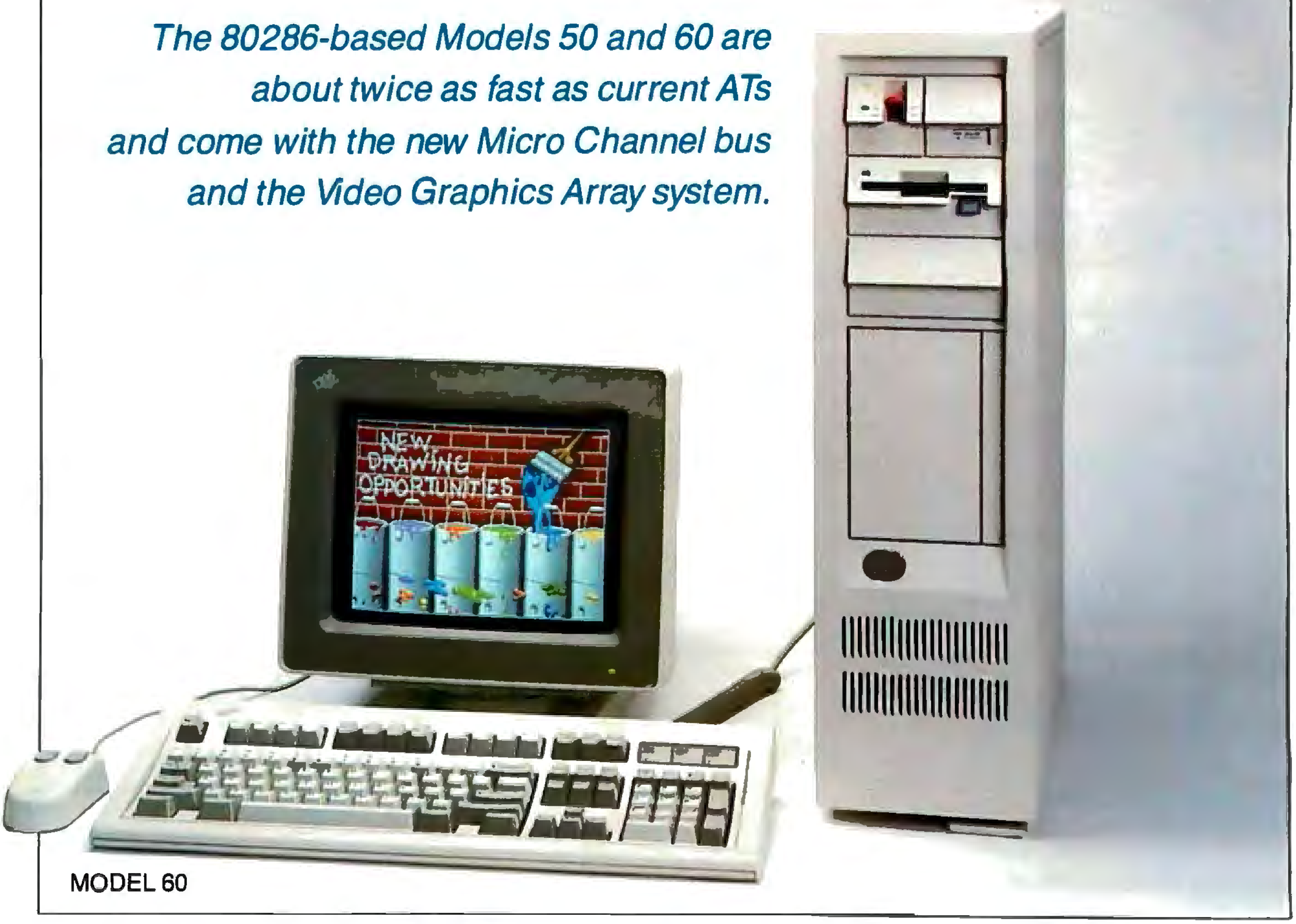
The Micro Channel uses asynchronous protocols for channel control and all data transfers. Two lines (–BURST and –TC) control block transfers of data. (Editor's note: *IBM uses the notation "–signal-name" to indicate an active low signal. We'll be using this notation here.*) A data transfer can go either to memory or to an I/O device, as determined by the state of a signal line (M/–IO). Two status lines (–S0 and –S1) define the transfer as a read or write operation. The lines –PREEMPT, ARB/–GNT, and ARB0 through ARB3 handle bus arbitration.

Lost or "phantom" interrupts can be a problem with concurrent processing. IBM said that to avoid the problem, it designed level-sensitive interrupts (replacing the edge-sensing interrupts used in the IBM PC) to allow for intrinsic sharing of the interrupts on all levels of the bus.

In the level-sensing scheme, each peripheral card toggles an "interrupt pend-

continued

The 80286-based Models 50 and 60 are about twice as fast as current ATs and come with the new Micro Channel bus and the Video Graphics Array system.



MODEL 60

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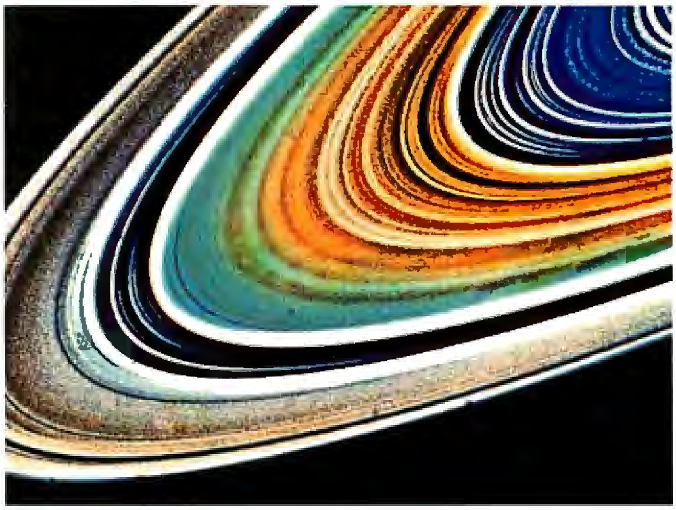

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ing" latch and holds the interrupt line active until it is serviced. By having the interrupt handler check all the cards' latches until none are pending, multiple peripheral cards can service interrupts without losing any of them. Level-sensing interrupts have the additional advantage of being resistant to line noise. In the Micro Channel, 11 prioritized interrupt lines use level-sensing interrupt signals. (From highest priority to lowest, they are -IRQ9 through -IRQ12, -IRQ14 through -IRQ15, and -IRQ3 through -IRQ7.)

Each slot also has several lines that are not shared (see figure 1, note 1) and others that are used to indicate the data-transfer width (16 or 32 bits wide; 8-bit transfers do not require a signal), card-selected feedback (which indicates slot occupancy at a specific address), and card setup (used to select cards during system configuration). The bus also contains provisions that allow cards to slow down the system speed, and in some cases to speed it up. By taking advantage of this, designers can build cards that will run in any Micro Channel system, whether it uses a 10-MHz 80286 or a 16- or 20-MHz 80386.

The AUDIO and AUDIO GND (audio ground) lines provide a single audio line that can be fed to the system's audio output or used as a path for an audio signal between peripheral cards. The frequency response of the line is 50 Hz to 10 kHz.

A central arbiter device (located on the motherboard) coordinates bus access. A card requests use of the bus by driving the -PREEMPT line active. The central arbiter permits an arbitration contest to take place as soon as the current card releases the bus: The central arbiter signals the start of an arbitration cycle (the ARB/-GNT line is driven to the arbitrate state), and the competing cards drive their arbitration levels onto lines ARB0 through ARB3. The fixed arbitration level for the card is set at system boot-up by a system configuration program. The card with the lowest arbitration level, and thus the highest priority, wins the contest. The winner gets access to the bus as soon as the central arbiter drives ARB/-GNT to the grant state.

The arbitration logic is fair in that it gives each card that entered the competition a chance at the bus before starting another arbitration contest. The arbitration mechanism, by the way, is the same as that used to arbitrate the DMA channels. This should reduce the work for some designers.

Because each card can have its own priority level, you might expect to have to set DIP switches to configure the system and its cards. But instead, a feature called Programmable Option Select (POS) automates the process. (As one IBM designer told us, "We think DIP switches are appropriately named.") Under POS, each card has its own identity code. Of more than 64,000 possible codes, IBM has reserved half for itself; the rest will be divided up among third-party developers. At boot-up, the system determines which cards are present and compares this with a list of cards stored in nonvolatile RAM during the last power-up. If it detects no new cards, the system loads any registers on the cards with data from the nonvolatile RAM. No switches or jumpers are needed on either the motherboard or on any expansion cards. If the system discovers a new card (or fails to recognize an old one), it can disable the card and give you the option of running a configuration utility to assign system resources to it. This ability to disable unknown cards also adds a measure of security; a malfunctioning peripheral card is less likely to remain on-line and crash the computer.

New Operating Systems

The PS/2 machines can use either of two new operating systems: PC-DOS 3.3, which is available now, and Operating System/2, designed for 80286 and 80386 systems, which won't be available until next year.

DOS 3.3 is an enhanced version of the DOS 3.2; it costs $120, but you can upgrade from previous versions of PC-DOS for $75.

DOS 3.3 solves some of the problems of its predecessors. For example, it can address a hard disk larger than 32 megabytes by dividing it into several partitions (former versions allowed multiple partitions, but PC-DOS could address only one of them).

Several new commands help DOS 3.3 meet the needs of an increasingly sophisticated environment. The APPEND command makes it easier for your program to find files in other subdirectories. CALL allows a batch file to execute another batch file, then return to continue its own execution. FASTOPEN is a terminate-and-stay-resident routine (the kind that gives you pop-up desk accessories) that creates a filename cache to speed up the reopening of recently used files; this command improves the performance of the computer when it has files that are opened and closed often (as with networked files).

IBM's OS/2 promises to have some very impressive capabilities when it becomes available. OS/2 is a multitasking system that can access up to 16 megabytes of memory. The new operating system will incorporate several features of IBM's newly announced Systems Application

continued

What IBM Didn't Do

For months (years even), rumors have been flying about what IBM would do with its next generation of microcomputers. Discussions with IBM personnel have contradicted many of the more prominent rumors. What follows is a list of what IBM says it did *not* do with its new machines.

- IBM did not alter the masks of the Intel 80286 or 80386 chip.
- IBM did not, and said it has no plans to, introduce a VM-type OS.
- IBM did not decide to hold off the 80386-based system until 1988. It is scheduled to be available in July of this year.
- IBM did not divide communications functions between the motherboard and a proprietary card to make third-party communications products harder to build.
- IBM did not arbitrarily change the bus and the card size—the 32-bit bus introduced on the Model 80 appears to be a solid foundation that can be built on for years to come, supporting multiprocessing and very high speeds.
- IBM did not change the floppies to 3½-inch drives without good reason; the double-sided microfloppies hold 1.44 megabytes of data and are faster and more reliable than 5¼-inch drives. IBM also predicted much higher densities to come on 3½-inch drives.

IBM *did* announce its own windowing system, the Presentation Manager; it will be about two-thirds Microsoft Windows and one-third proprietary. The windowing system, shown in simulation, looks significantly different from Windows, the Macintosh environment, GEM, or anything else. Microsoft has announced that Windows 2.0 (which will run under DOS 3.3, but not OS/2)will be visually identical to the Presentation Manager..

Architecture (SAA), which will reportedly present a common user interface across all of IBM's systems. Eventually, it will have a user interface based on windows, graphics, and icons. And a later Extended Edition will include a relational database and communications functions.

The first version of OS/2, called Standard Edition 1.0, will appear in the first quarter of 1988. It will have no graphics or windows and will cost $325.

The next version of OS/2, Standard Edition 1.1, will contain a Presentation Manager, which IBM said will include graphics, windows, typographic-quality text fonts, and icons. The Presentation Manager is based on Microsoft's Windows and on the Graphical Data Display Manager (GDDM) interface on IBM's 3270 systems. However, IBM said that the Presentation Manager's interface will be significantly different from those of Windows, the Apple Macintosh, or Digital Research's GEM.

A later version of OS/2, the Extended Edition, will have all the features of the Standard Edition plus a version of IBM's DB2, a mainframe-based relational database, and a version of SQL, IBM's structured query language. In addition, it will

continued

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Bluespeak

IBM is one of the few entities that, like Big Brother or the Cheshire Cat, can make a word mean what it wants it to mean. If you should ever encounter unfamiliar words in reference to IBM products, the following list might help:

IBM word	Real-world definition
adapter	peripheral card
channel	bus
facility	usually a combination of hardware and software
feature	a hardware add-in, usually a peripheral card or a disk drive
fixed disk	hard disk
pel	pixel
planar	motherboard

contain an advanced communications manager, which lets users communicate concurrently via several different protocols. It will cost $795. For more details on the general structure and operation of OS/2, see "Microsoft's New DOS," on page 116 of this issue.

Only The Beginning

Overall, the PS/2 computers are a respectable design with considerable room for growth. One of the most significant aspects of the announcement is the announcement itself: Now that IBM has shown its hand, the rest of the industry can move forward again.

We were pleased to find that IBM has not, as some rumors said, created a proprietary (and therefore hard-to-copy) computer by having Intel create a custom version of the 80286 and 80386 processors. Though IBM is secretive about many aspects of its design, it has pledged to document BIOS entry points and Micro Channel signals, thus opening the design to software and peripheral-card developers (but not to designers of compatible computers). A critical issue for companies making PS-compatibles is whether or not IBM will sue to defend its patent of the Micro Channel bus.

Unfortunately, the absence of the OS/2 software until sometime in 1988 leaves us, for now, with a line of computers that are little more than high-speed IBM PCs with large hard disks. Worse, software to exploit the unique features of the Model 80's 80386 processor appears to be even farther off (OS/2 is written in 80286 machine code and does not use any 80386-specific features). The PS/2's ability to run multiple processors off the Micro Channel bus and to run up to a gigabyte's worth of programs under OS/2 offers a promise of high performance sometime in the future. We will not be able to gauge the true worth of this product line until we begin using these new features. ■

Editor's note: *In the next issues of BYTE, we'll continue to examine the underlying technology and implications of the new IBM hardware. Our coverage will include full product reviews of the new systems. And in a new series of articles called "The New Generation" we'll begin in-depth ongoing comparisons between the two major new families of 32-bit personal computers: the 80386-based machines (such as the IBM PS/2 Model 80), and the 68020-based machines (such as the Mac II).*

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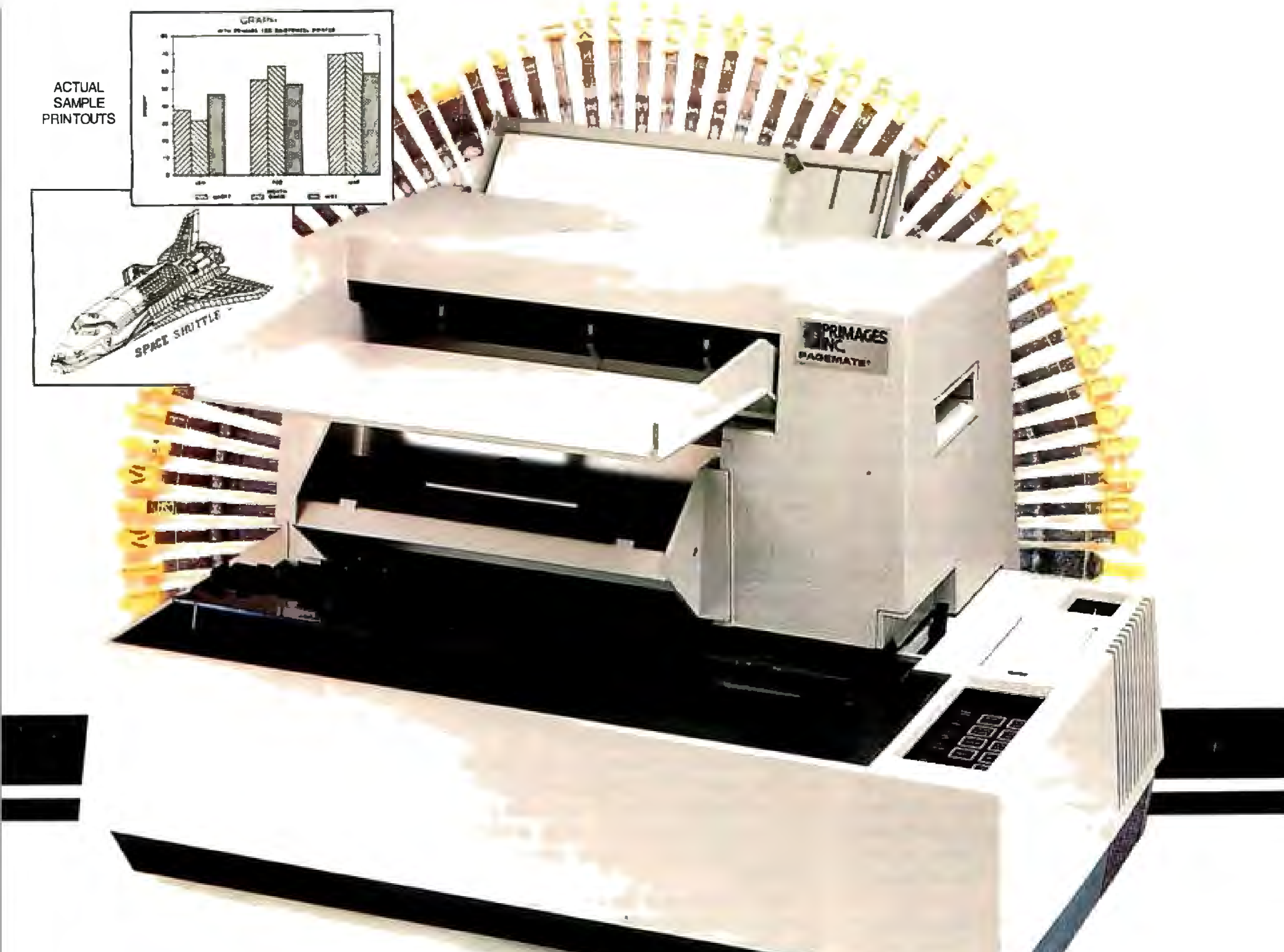

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Eva White and Richard Grehan

Microsoft's New DOS

[Editors' Note: *We based this article on our evaluation of alpha-release software and documentation, and on a series of interviews with Gordon Letwin, chief architect of the OS/2 project.*]

In 1981, IBM introduced MS-DOS 1.0 with the Intel 8086-based IBM Personal Computer. The operating system was very similar to the then-predominant CP/M. It was actually a redesign of an earlier operating system written to mimic CP/M's functions and style of operation.

Through the years, Microsoft has steadily built on MS-DOS: version 1.25 added support for double-sided disks; version 2.0 provided for Unix-like hierarchical file structure and hard disks; versions 3.0, 3.1, and 3.2 added support for 1.2-megabyte floppy disks, higher-capacity hard disks, Microsoft Networks, and 3½-inch floppies. With each enhancement, compatibility with preceding generations of MS-DOS was an important—and restricting—consideration; it kept Microsoft from adding significant new functions to the operating system.

What's more, the 16-bit 8086 is becoming obsolete in a world increasingly dominated by 32-bit microprocessors. Microsoft is attempting to overcome these limitations with a new operating system that harnesses the power of Intel's 80286: OS/2.

OS/2 is an 80286-based, multitasking, single-user operating system that supports a single real-mode application and a theoretically unlimited number of protected-mode applications (the amount of RAM available determines the number of simultaneous tasks OS/2 can support before performance becomes unacceptably slow). OS/2 will also run on 80386 machines, since the latter's instruction set is a superset of the 80286's.

In developing OS/2, Microsoft's goal was to provide system software that would be suitable for an office-automation environment. Everyone would have their own computer with which they can perform multiple tasks and communicate through network links. [Editor's note: *For a discussion of architectural considerations, see the text box, "Design Goals," by Gordon Letwin.*]

OS/2 provides a powerful, flexible foundation that will make the eventual migration to the 80386 relatively painless. While this new operating system will only run on a machine using an 80286 chip (or higher), the designers have provided an impressive amount of downward compatibility for the current base of DOS applications.

Dual Modes

The 80286 (used in the IBM PC AT and compatibles) offers two modes of operation: the real mode and the protected mode. In the real mode it runs programs written for the 8086 unaltered. In the protected mode it provides, through hardware, protection and virtual-memory management for multitasking. But incompatibilities between the two modes prevent most 8086 programs from running without modification under the protected mode of the 80286. (The 80386's virtual 8086 mode should solve these problems.)

In protected mode the operating system provides virtual-memory management, task management, and protection. With virtual-memory management, your applications get access to the 16-megabyte real-address space of the 80286 and a 1-gigabyte virtual-address space. A three-level priority scheduler allots processor time slices among the tasks. The operating system takes advantage of the 80286's protected mode to isolate tasks from one another.

Under OS/2 real-mode applications can do everything they could do under previous versions of MS-DOS—but no more. This shouldn't be much of a problem because most people will use the real-mode area—referred to as the 3.X box—to run their DOS 3 applications. (In this article, DOS 3 means all versions of DOS 3.) Anyone developing new software under OS/2 will probably prefer to use the protected mode where the application programmer interface (API) is richer and the debugging facilities are more sophisticated.

Figure 1 is a memory map of OS/2. The operating system itself sits at the low

Multitasking (with semaphores, pipes, and queues), virtual memory management, protection, and compatibility with existing software are just some of the features of Microsoft's OS/2.

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end of memory, occupying about 90K bytes. The 3.X box resides just above it. Notice that the "high-water mark" of the 3.X box is user-adjustable between an address of 512K bytes and 640K (the actual memory available to the 3.X box is that address less the size of the operating system). Sitting above the high end of the 3.X box are BIOS routines and screen memory, and above them are the nonmovable protected segments and nonmovable, nonswappable code (this is where the memory management code for disk swapping resides—you can't swap the swapping code). Finally, the top end of the system's memory is the domain of the swappable protected-mode applications. (Any memory between the top of the 3.X box and the BIOS region also goes to protected applications.)

A user-alterable argument in a configuration file lets you disable the 3.X box entirely. If you do this, you can run OS/2 in as little as a megabyte. If you want to run the 3.X box, however, the designers recommend at least 1152K bytes of memory (640K bytes below the BIOS area and 512K bytes above the 1-megabyte line). Some memory-expansion cards use linear addressing for their memory above 1 megabyte. In this case, any memory beyond 1 megabyte that the system finds at boot-up goes to protected-mode applications. Other expansion cards window their memory into a fixed-size block within the lower 1 megabyte. The 3.X box can use this memory, and according to Microsoft, such memory cards should work correctly in OS/2.)

Screen Groups

OS/2 uses screen groups to manage multiple tasks on a single machine. Think of screen groups as a series of virtual PCs. The session-manager portion of the operating system handles the switching from screen group to screen group.

In the version of OS/2 we looked at, the session manager displays a menu showing the current screen groups. If you have configured the system for a 3.X box, you will see one real-mode screen group that uses the command processor COMMAND.COM and a selection to "start a program," which, each time you choose it, starts a new protected-mode screen group using the protected-mode command processor, CMD.EXE. To switch to another virtual PC, you press the session-manager key combination, Control-Escape to returns to the menu of the current screen groups. Pressing Alt-Escape rotates you through the menu. You press the Return key to choose a menu item.

According to Microsoft, the final version of OS/2 will run with Microsoft Windows Presentation Manager, the graphical user interface, and a mouse. It

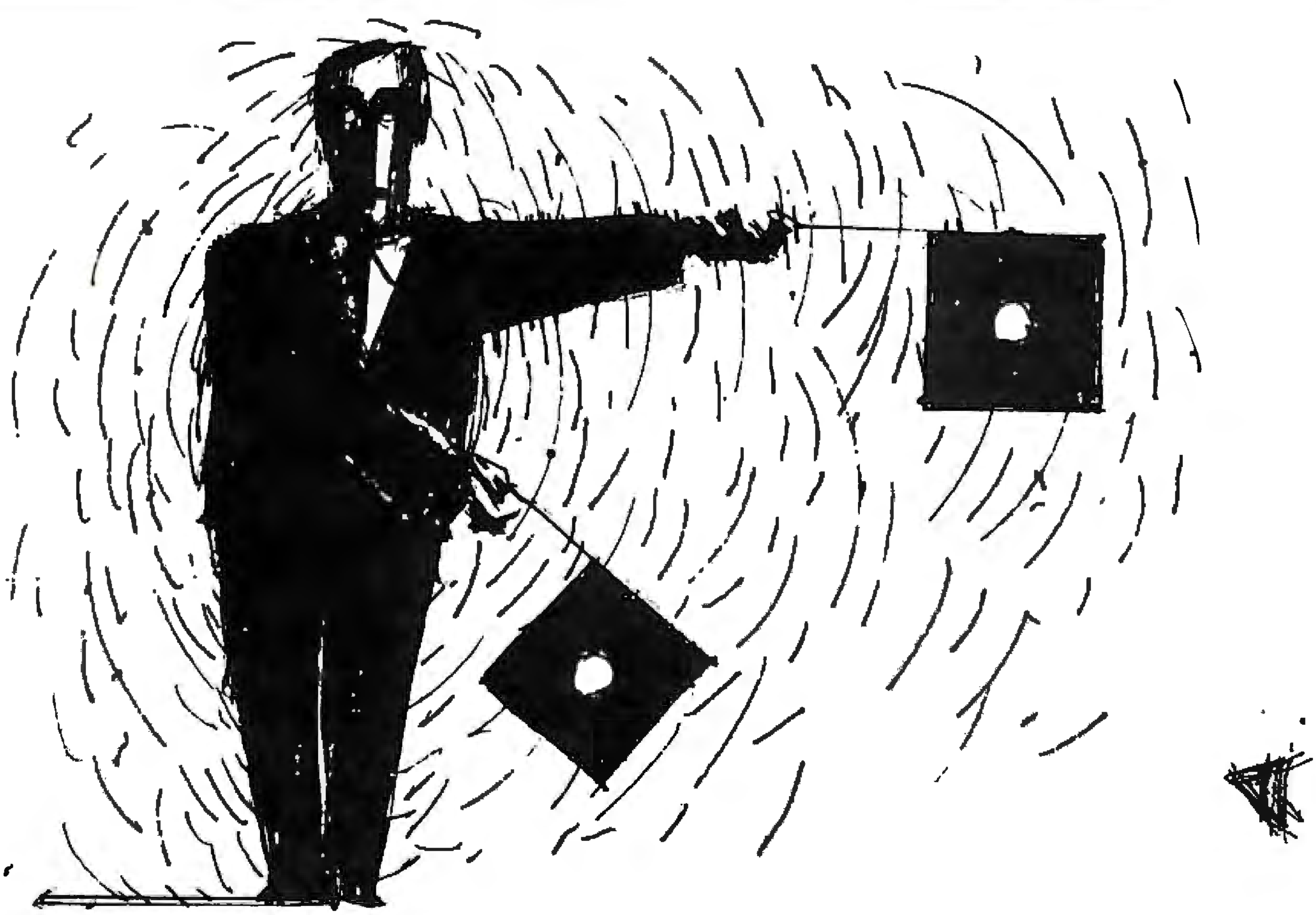


Illustration by Maciek Albrecht

will work as just described except the session manager menu will be a drop-down menu on the current screen group; you click the mouse on a menu option to change to another screen group. The Presentation Manager is the protected-mode version of the real-mode Microsoft Windows already available for DOS 3. It will handle the output of separate tasks to a single physical display.

Because of screen groups, it should take you very little time to get comfortable with OS/2. The protected-mode command processor gives you the familiar DOS commands such as `attribute`, `chkdsk`, `diskcopy`, and so on. One new command available in protected mode, `detach`, lets you start a background process. (More information on the multitasking scheduler later in this article.)

Since OS/2 was designed as a single-user system, you do not need a command for logging off the system. But before turning off the computer, you must check your screen groups and shut down all tasks gracefully (similar to earlier versions of MS-DOS, only now you have to remember to exit more than one process).

The disk structure of OS/2 is identical to the structure of DOS 3, so it can read disks you are using in your PC. While this means that OS/2 continues to carry all the limitations of the old disk directory structure (e.g., the 32-megabyte disk volume limit), the designers have laid the groundwork for removing these limits and adding file protection (file I/O calls contain extra arguments that will be used for this purpose in a future operating system).

Under OS/2, it will be very important to give volume names to your floppies. In a multitasking environment, when a number of programs are executing simultaneously, the odds of writing to the wrong floppy are extremely high. The designers added a field to the disks so that each floppy carries a unique ID number. This ID is derived from the user-entered disk volume name and a system-generated 32-bit binary number. You should be sure to use the DOS `label` command for any DOS 3 disks that don't have a name before using them under OS/2.

Protected Mode

If you've done any programming under existing versions of MS-DOS, you are already familiar with all the features available to OS/2's 3.X box. It is obvious, then, that the real power of OS/2 lies in its offerings to the protected-mode applications. Consequently, for the remainder of this article we'll concentrate on the protected-mode portion of OS/2 (unless we specifically state that a certain function is available to real-mode applications).

Programmer Interface and Dyna-Links

While the user interface of OS/2 is similar to previous versions, the application programmer interface (API) has been dramatically reworked. The most significant change is that programmers will no longer issue interrupts for services. All work in the system is done through a generalized procedure call interface implemented through dynamic links (dyna-links, for short).

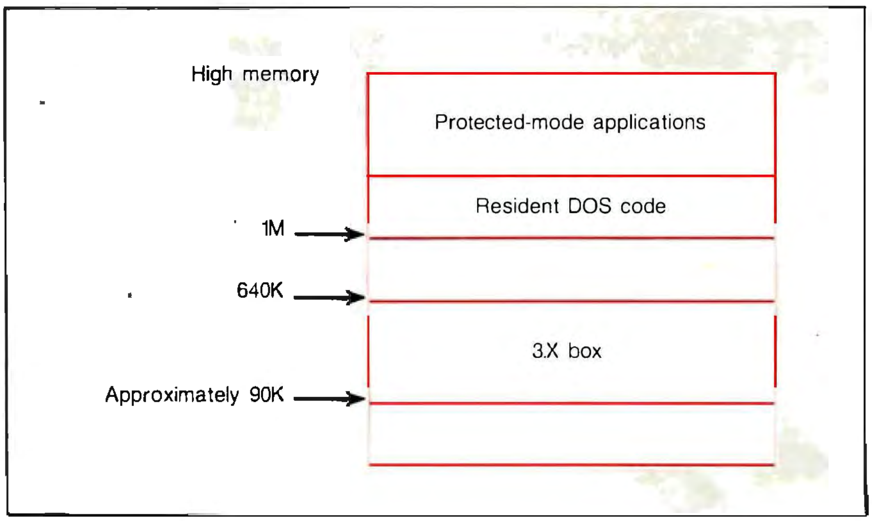


Figure 1: *A memory map of OS/2. This figure shows a system configured for both protected- and real-mode applications. You can set up an OS/2 system for protected-mode tasks only, in which case the 3.X box disappears and protected-mode applications can use its memory. Also, you can adjust the 640K boundary at the top of the 3.X box to some lower value, freeing the memory between it and the BIOS area for use by protected-mode tasks.*

Using a procedure call mechanism for requesting system services is quite an improvement over using interrupts. It provides one interface to all system services, hides the implementation of those services, and allows routines to have more meaningful names. When making far calls to routines that expect their arguments to be passed to them on the stack, programmers will now use the Pascal calling convention. Several C compilers can specify the Pascal calling convention.)

Another advantage of using a procedure call is that you cannot overload one of the software interrupts. Interrupt vector redirection in DOS 3 often causes problems when several TSR (terminate and stay resident) pop-ups are installed on the same machine and end up fighting over control of a single vector. Permitting such activity on a multitasking system could be disastrous. (Applications that execute in the 3.X box can continue to redirect vectors and use `INT 21hs` just as before.)

The new call scheme allows much of the operating system to be stored on disk in dyna-link libraries and pulled into memory only as needed. Dyna-linking means a program's external references to subroutines in other segments are resolved at run time rather than at link time. OS/2 delays binding of routines by using special "stub code" in place of the actual code in the executable file generated by the linker. This stub code contains the module name and entry point of the actual code.

There are two kinds of dyna-links: preload and load-on-demand. OS/2 loads segments marked preload into memory when the user starts the application and faults-in those segments marked load-on-demand as the application needs them.

So that a dyna-link routine operates efficiently in OS/2's multitasking environment, each routine has three segments: code, instance data, and global data. The code segment's function is obvious: it is the executable portion of the routine. The system creates an instance-data segment for every user of the routine (i.e., if several tasks call the same dyna-link routine, each task will get its own instance-data segment associated with that routine). However, only one global data segment is created for its associated dyna-link routine, regardless of how many customers the routine has.

Dyna-links give OS/2 the flexibility to handle future hardware and software changes efficiently. With them, you can package such services as database engines in dyna-link libraries and these libraries need not even come from Micro-

continued

Design Goals

by Gordon Letwin

Microsoft designed OS/2 with the future of the office automation environment in mind—where microcomputers on every desktop handle the routine information-manipulation tasks of a modern office, and the rapid flow of information via networks replaces the slow flow via paper. We built OS/2 so that it achieves the following goals:

- It provides device-independent graphics drivers, but it does not introduce any significant overhead in doing so.
- It gives applications direct access to high-bandwidth peripherals, but it virtualizes the use of those peripherals to prevent cross talk.
- It provides a fully customized environment for each program and its descendants, yet it also provides a standard environment that is unaffected by other programs in the system.
- It provides a protected environment to ensure system stability. It still provides applications with all the capabilities they had under nonprotected systems, but it doesn't limit the capabilities they can add in the future.

OS/2 is similar to traditional multitasking operating systems in many ways: It provides multitasking, scheduling, disk management, memory management, and so on. But it is as different from them as an office desktop environment is different from a multiuser mainframe environment. Traditional multitasking systems were designed at a time when computers were very costly; maximizing the machine's throughput and utilization was important.

Powerful microcomputers are now relatively inexpensive. In designing OS/2, we attempt to maximize the machine's response and utility to its user.

OS/2's emphasis on a graphical user interface is a departure from traditional operating systems. [Editor's note: *The first release of OS/2 will not provide graphics support in its video I/O package; programs will have to do their graphics work through direct device control.*] A powerful graphics capability is essential to an office-automation operating system. Such facilities were rare in minicomputer operating systems because they required a lot of memory and compute power to drive high-resolution displays. Today's microcomputers have the necessary memory and CPU power.

OS/2 also differs from traditional minicomputer operating systems in its management of devices. The classic device driver interface is too slow and one-dimensional for effective use of the graphics-display screen and the mouse, yet some system interface is needed to provide display-device independence. Instead of screen device drivers, OS/2 uses a set of three dynamic-link packages to provide a high-performance yet device-independent interface to the screen, mouse, and keyboard. Packages such as Microsoft Windows can partially replace these dynamic-link routines, letting Windows or similar packages seamlessly support non-Windows programs.

Most minicomputer systems virtualize—or share—all devices among the running applications. Since users are physically remote from the CPU, their only personal system is their terminal and a low-bandwidth OS-based interface. OS/2 virtualizes some system resources such as system RAM and disks, but allows applications direct access to private devices such as special display hardware, light pens, digitizer tablets, and so on. Such direct access is critical for good performance from high-bandwidth devices.

OS/2's environment is protected so that applications cannot help themselves to what they need by manipulating system memory or devices, but this also restricts an application's ability to effectively add new features to the system. This means that OS/2 must provide functions to support anything that a current or future application might need.

Since Microsoft cannot possibly anticipate all conceivable programs, the OS/2 design includes a variety of adaptable, expandable interfaces that can accommodate future requirements. With dynamic linking, for example, you can access services from DOS, from library routines, and from other processes in a flexible yet controlled way. You can upgrade the system, add packages and services, and process and distribute data across the network, yet the clients of those services will continue to see an unchanged interface to those services.

A multitasking system runs many programs in one computer. Ten programs at once means that the chances of a program bug cropping up are ten times greater. Worse, an errant program may damage another, thereby hiding the true cause of the problem, or perhaps just producing an incorrect result. OS/2 is designed so that errors are isolated to the program that caused them. The program's normal operation—memory consumption, keyboard usage, and so on—does not affect others. It also restricts a program's ability to interfere with others by the manipulation of global resources, such as the screen or keyboard. A protected-mode application can control the screen and keyboard within its own screen group, but it cannot prevent the user from switching to another screen group and interacting with the application running there.

It is commonly thought that applications programmers are at the mercy of the systems designers because applications have to use the facilities provided by the system. Actually, the opposite is true; systems designers must ensure that existing applications continue to run on any new release.

An operating system can only succeed when there is a good selection of popular applications that will run on it. Those applications, in turn, are only written for already successful systems. This catch-22 means that downward compatibility with earlier DOSs is critical to bootstrap OS/2 into the marketplace. OS/2 provides this compatibility by dedicating one of the screen groups as the 3.X box. A lot of effort went into providing DOS 3 compatibility, but there was no question that it had to be there.

In designing OS/2, we had to strike a balance between many sometimes contradictory goals: We had to provide a flexible operating system environment, yet that environment had to be fast. We wanted to provide application programmers with a rich API that would form a stable application base for years to come. But we couldn't do this at the expense of people who have a large investment in applications running under earlier versions of DOS.

We saw the fundamental incompatibility between protected mode and real mode as our one chance to break compatibility with elements of earlier versions of DOS that are unsuitable for a multitasking, networked, protected environment. Since programmers will have to modify their programs slightly to run in protected mode anyway, we took this opportunity to have them modify the programs a bit further and stop undesirable features from being passed on to future versions of the system. Seeing this break in compatibility as a one-time event put us under a lot of pressure, but we believe that with OS/2, we have designed an operating system that we will be able to support for a great many years and releases to come.

soft. A programmer can use a dyna-link package to extend the operating system. He can install it and then call the entry points as though they were part of the operating system. In fact, the system, screen, mouse, and keyboard services are actually dyna-link packages. A program like Microsoft Windows can simply replace the standard screen and keyboard driver with its own so that a program—without knowing it—is then "talking" through Windows.

Scheduling

OS/2 uses a preemptive three-level priority scheduling system. Each task has a set amount of CPU time. Its duration (and how frequently the task is scheduled) depends primarily on the priority category assigned to the task and secondarily on the task's CPU and I/O usage history. (See the text box "Scheduling Example.") The three categories are:

- *Forced-run priority.* This category is for top-priority processes that might cause a functional failure unless they produce a response within a given amount of time. A good example is a network program where you'll be logged off if you don't respond to a query fast enough.
- *Middle-range priority, foreground and background.* The foreground screen group has control of the system display and keyboard, while background screen groups are not currently on-screen. At any given moment there is only one foreground task, but you can have any number of background tasks.
- *Background priority.* Not to be confused with middle-range background, tasks in this category are the lowest-priority in the system. Simply put, background tasks run in whatever time is left over. (Microsoft said that the designers didn't have any candidates to run in this category; they added it because it was symmetric with the rest of the scheduling system.)

Within this scheme, the task running in the 3.X box occupies its own category: If an application is running in the 3.X box and you switch it off-screen, it becomes completely inactive. (However, the converse is not true; while the 3.X box application is on-screen, protected-mode tasks continue to execute.) The OS/2 designers do not allow a real-mode application to run when switched off-screen because such an application will probably have no idea it is executing in a multitasking environment.

If a real-mode program switched off-screen were allowed to execute in the background it could continue to write data directly to screen memory, obliterating whatever the foreground task was displaying.

Threads

There are situations in certain applications where it would be useful to have multiple streams of execution within a task, but where it would be inappropriate to spawn child processes. For example, in a spreadsheet program you might want to perform a recalculation of the cells visible on-screen, then—while recalculating the off-screen cells—prompt for more input.

OS/2 allows multiple streams of execution, called *threads*, within a single protected-mode task. Only register contents and stack are private to a thread. Every thread in a process can access all the other resources associated with that process. Consequently, if one thread opens a file, then all the other threads within that task can perform I/O operations on the file.

Since each thread has its own run history, you can assign a priority level to each thread. However, a thread is only visible to the process that created it; hence, no task can alter the priority level of (or kill) another task's threads.

Interprocess Communications

OS/2 includes a number of sophisticated methods by which tasks can communicate with one another. Anyone who knows Unix is already familiar with the concept of a pipe; OS/2's pipes are functionally identical to Unix pipes. In brief, a pipe allows for the exchange of data between related processes: Both processes execute concurrently with the data moving through it as a stream of bytes so that a pipe functions as a first-in/first-out data structure. Programs communicate with a pipe as they would a sequential file; the sender opens it for writing (using a standard file-open call) while the receiver opens it for reading.

A queue is a kind of enhanced pipe. It differs from a pipe in that it can be set up between unrelated processes. Queues allow processes to exchange structured rather than serialized data as pipes do. A queue has some additional features such as receipt acknowledgement: When the program at the receiving end of a queue receives the transferred data, the queue informs the sender. Any number of tasks can write to a queue, but only the task that created the queue can read from it.

Shared memory is an unstructured segment of memory that a task creates and designates as being accessible by other tasks. The creating process assigns a unique name to the segment, and other tasks in the system that have this name

continued

Scheduling Example

To give you an idea of OS/2 scheduling methods, let's look at an example arrangement of tasks (see figure A). Screen group 1 is the active screen group, and in it we are executing CMD.EXE. We have launched JOB1, and it has spawned two child tasks, DIR and JOB2. We have also started up a mailer daemon as a separate process that requires no keyboard interaction. Screen group 2, not currently on-screen, is assembling a source code file with the MASM assembler. On the real-mode screen group, we are doing spreadsheet work with Lotus 1-2-3. Finally, on some other screen groups we are running a time-critical network printer-driver task and a true background-priority job that is calculating π out to hundreds of decimal places.

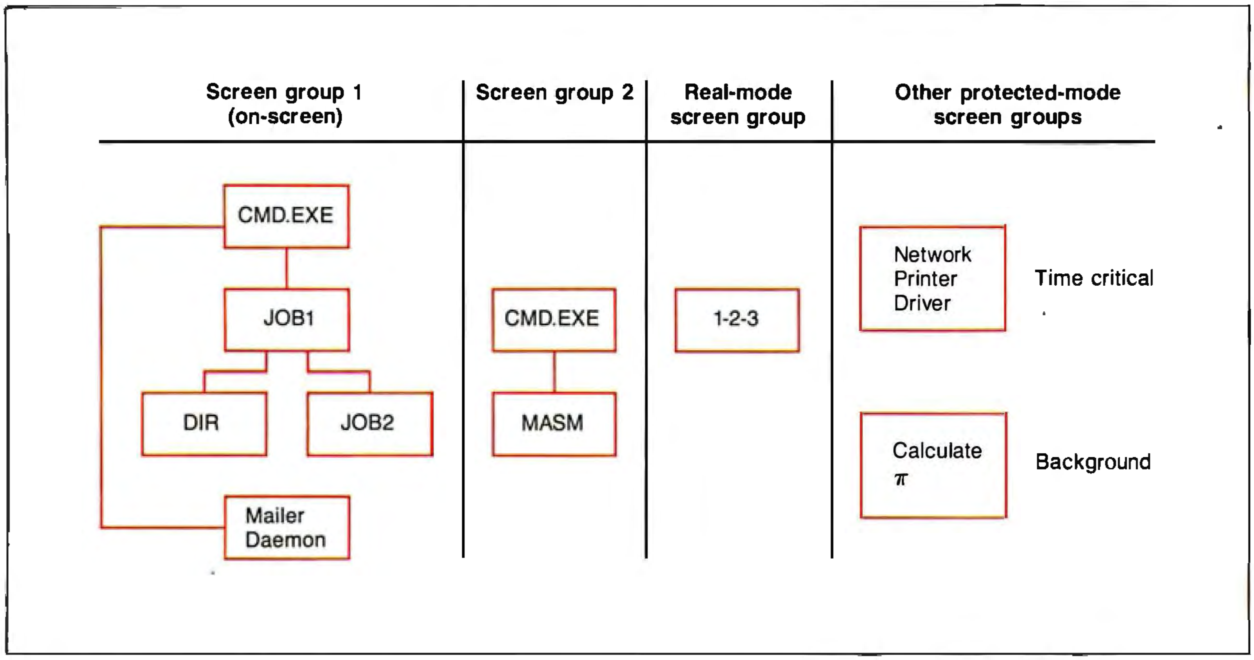
In what order does scheduling take place?

Of course, the time-critical task is top priority, so the network printer driver gets scheduled first (and most frequently). Next come the tasks in screen group 1: JOB1, DIR, and JOB2. If only one of those processes needs to run, then that task is scheduled. However, if all three need to run, then a secondary level of scheduling looks at the run history of the tasks and schedules them based primarily on CPU and I/O usage. (If the operating system sees that a task performed I/O recently, then that task will be scheduled again quickly in the hope that it will do more I/O in the future. Since I/O in OS/2 is interrupt-driven, a task awaiting I/O will release the CPU, making it available for other tasks.)

The mailer daemon is scheduled next, boosted in priority because it is executing in the active screen group. Notice that this task is scheduled behind JOB1, DIR, and JOB2, since it is not interactive with the display or keyboard. MASM, running in an inactive screen group is scheduled next. Finally, the program to calculate π is given any time left over. This task might do well if all other tasks are awaiting keyboard I/O.

Since the real-mode screen group is not active, the 1-2-3 program is not given any CPU time at all. OS/2 gives no time to real-mode applications that are switched off-screen. This is because they might attempt to write directly to screen memory and overwrite the output of whatever program is currently in the foreground.

Figure A: *A sample arrangement of tasks within screen groups.*



may perform an operating system call to obtain a copy of the segment's selector.

With a flag, one task can trigger an event in another task, as long as the receiving task is set up to receive the flag. In operation, flags are software-generated interrupts similar to Unix signals. Task A defines a flag event and attaches an event-handling routine to it so that when task B triggers the event, task A is interrupted and its event-handling routine takes control.

Semaphores let tasks and threads coordinate accesses to an access-limited resource; only one task at a time can hold a semaphore. As an example, you might set up a semaphore to control access to your printer. When one task calls for use of the printer, it first sets the semaphore. Other tasks that attempt to print will be blocked until the semaphore is cleared.

OS/2 supports two kinds of semaphores: system semaphores and RAM semaphores. System semaphores, though slower, are more carefully controlled by the operating system. Specifically, a system semaphore won't lock up. If the holder of a system semaphore crashes before it releases the semaphore, the next task waiting in line for the semaphore gets it and can even discover that it was allowed to enter because its predecessor has died.

RAM semaphores are for communication among threads within a task. A RAM

continued

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Family API provides a compatibility bridge between the two sides of OS/2, giving products an easy way to migrate to OS/2's protected area.

semaphore exists in a piece of memory shared by the threads and, since it is entirely RAM-based, it operates faster than a system semaphore.

Note that the interprocess communication features of OS/2 have added a host of new data structures that must exist in a multitasking world. Each individual queue, semaphore, and shared memory segment must have a unique name and access to them has to be controlled. The designers of OS/2 have therefore devised the idea of the file-system name space: a concept that extends the method by which disk files are named to include any object in the system that requires a name. The syntax that governs disk file-naming conventions now controls queues, semaphores, and shared-memory segments. (For example, to create a queue, you must specify its name by including the prefix \ QUEUES \ —a valid queue name might be \ QUEUES \ payroll.dat.)

As a result, file-permission mechanisms that Microsoft hopes to add in a future version of OS/2 will apply immediately to shared data structures. The networking architecture in OS/2 lets you call a file that is on another machine in the network as easily as if it were on one of your local disk drives. Thanks to the file-name space, you will be able to name queues across the network, so that a task on your machine could send data through a queue to a task on another machine. (This feature is not scheduled to be available in the first release of OS/2.) Additionally, since semaphores are named items, this paves the way for a future release that would make them pseudofiles (a component of the semaphore would be recorded on the disk). This would make semaphores easier to manipulate. Also, if the system crashes, a critical semaphore could be saved and then restored to its former permission level when the system was brought back up.(Currently, Microsoft has no plans to allow shared memory to be accessible across the network.)

Monitors

One problem that arises from OS/2's virtualization of the screen and keyboard is that it creates an insulating layer between an application and its hardware. Often, a programmer would like to directly inspect and modify the stream of data passing through a device driver (prior to any filtering that the driver might perform). Take, for example, a keyboard device driver that outputs ASCII sequences. Since there are no ASCII sequences that use the Caps-Lock key, a program that indicates on-screen that the Caps-Lock key is engaged (several popular word-processing and spreadsheet programs do this) would be unable to determine the state of that key from the output of such a driver.

A monitor is a program you attach to a device driver that has access to all the characters passing through the driver. A monitor can remove or add characters, or simply watch them go by in the data stream moving through a device driver. You can attach more than one monitor to a single device driver; OS/2 provides routines for registering a monitor with a device driver so you can set up an entire chain of monitors with complete control over the order in which the monitors gain access to the data stream.

Note that monitors let you actually add code to the device driver. And, because the monitor receives data from the device driver, modifies it, and passes it back to the driver, the monitor's presence is invisible to any processes using the driver. (The OS/2 designers said that monitors allowed more global action than they liked; here is a means by which one task could affect another. However, there were strong demands for monitors—Superkey and SideKick need this kind of interaction with the hardware that monitors furnish.)

Since the operating system virtualizes the keyboard, each screen group appears to have its own keyboard device driver and no interaction problems occur when different screen groups register their own keyboard monitors. The designers of OS/2 had to program the keyboard driver so that monitors could not remove the "hot key" (the key used to switch screen groups) from the data stream; otherwise, a monitor could lock a screen group onto the screen.

Family API

Microsoft has designated a subset of the function calls available to the OS/2 protected-mode programs as the Family API. Microsoft chose the members of this subset so that programmers could write applications that would run under both OS/2 and DOS 3 (and of course, the 3.X box).

Since Family API–compatible applications can run under DOS 3, this means that Family API functions do not provide access to any of OS/2's multitasking features (e.g., semaphores and queues). However, this does provide a compatibility bridge between the two sides of OS/2, giving current products an easy way to migrate to OS/2's protected-mode area. (See the text box, "New .EXE Format" for further information.)

Performance Issues

Performance was a top priority in the design of OS/2, and providing it within a multitasking environment is more difficult than you might think. Consider the following scenario: Suppose two protected-mode tasks are running under OS/2. One makes a request to the operating system for a block of memory, and the operating system determines that there is no single block of free memory large enough to satisfy the request. So the operating system begins moving segments in a compaction process (to consolidate the fragmented free memory space), which might take up to 30 milliseconds. But then a task with a forced-run priority level asks to be scheduled and the operating system must grant the request within 5 ms. A dilemma arises: What happens if the second task asks for access to one of the segments being moved?

OS/2 solves this by marking the segment being moved as being swapped out. It then puts another mark on the segment, indicating that the segment is in the middle of being moved. OS/2 then transfers control to the time-critical task. Now, if the task requests the marked segment again, it gets a segment-swapped-out fault. When the operating system's fault handler takes control, it examines the situation and sees the true cause of the fault. It then completes the move and tells the operating system "I have finished moving this segment for you," and finally returns control to the time-critical task.

An important goal for the OS/2 design team was to ensure that I/O throughput was kept as high as possible. OS/2's new video I/O routines are much faster than the old screen-interrupt routines; only a few programs might find the new routines too slow (in the past, most commercial applications sidestepped the DOS screen routines).

But suppose you have written a program that wants to output to the screen and needs the throughput that it can obtain only by writing directly to screen memory. This is at best a difficult job in any multitasking system. In OS/2's virtual screen environment, accessing video memory directly is particularly dangerous since the user might switch screen

continued

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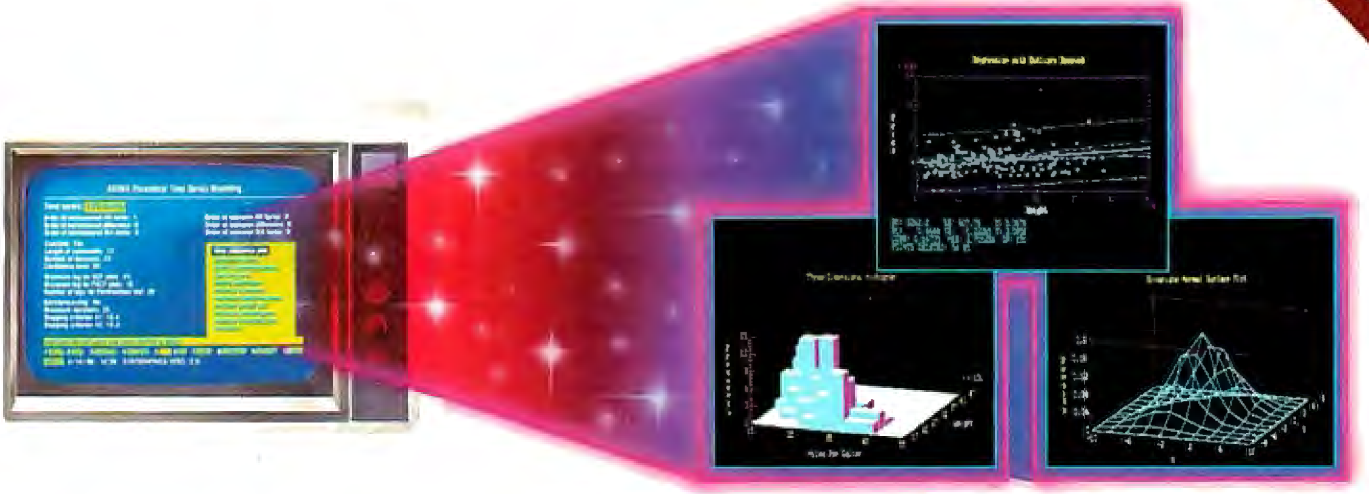

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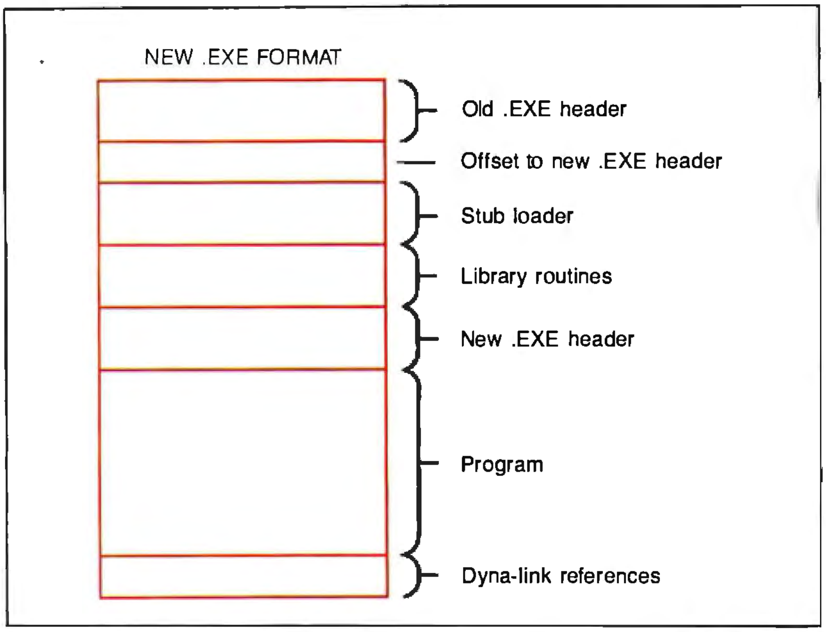
New .EXE Format

With the development of the Family API definition, Microsoft has enabled developers to write code that operates either in the DOS 3 or as a protected-mode application under OS/2. However, don't get the idea that you need only recompile existing 3.X applications into the new .EXE format to get them to run on the protected-mode side of OS/2. You will also have to recode the operating system calls to comply with the Family API specifications. The designers of OS/2 created an executable file format that both the protected-mode or real-mode sides of the operating system can read. Figure A shows a simplified diagram of this new .EXE file format.

This format is a superset of the structure of .EXE files in current versions of MS-DOS. If you are running in the protected-mode side of OS/2 and you execute a new .EXE file, the operating system looks at a value stored at a specific location in the old .EXE header portion of the file and determines that the file is in the new .EXE format. In this case, the operating system ignores the stub loader and library routines and loads the user program. OS/2 then fixes up any dyna-link references that must be satisfied at load time and passes control to the program.

However, if you execute such a file under DOS 3, the entire file is brought into memory (the DOS 3 loader assumes that the file is in the old .EXE format). Control then transfers to the stub loader. The library routines are DOS 3 implementations of Family API dyna-link library routines, and the stub loader code reroutes the program's dyna-link references to point to this library code. Finally, the user program gains control and executes.

Figure A: *Diagram of the new .EXE file format. Files conforming to this arrangement will run in both the real-mode and protected-mode sides of OS/2.*



groups in the middle of a screen write.

To handle this situation, OS/2 provides a function that programs can call to obtain exclusive access to the display. The function returns a value indicating that the calling program has access to the screen; it is then that program's responsibility to perform its I/O as quickly as possible and release the screen. (There is a time-out period to guard against a program's grabbing the screen and never releasing it.) During the time that the program has control of the display, the system hot key is disabled.

A Transitional Product

OS/2 provides a high degree of compatibility with the existing software base without compromising the robust API for developers of future applications.

Compatibility has become such a powerful consideration in the microcomputer industry that a staggering amount of work is being directed toward that end: The designers of OS/2 said that over half of their effort went into providing the 3.X box. Parallels elsewhere in the industry include the Apple IIGS, where a major portion of the design effort was devoted to maintaining compatibility with the Apple II series; the Mac II, where special provisions had to be devised to support the "old" 24-bit addressing of the Macintosh within the Mac II's new 32-bit architecture (firmware routines compatible with those in the Mac and Mac Plus were also incorporated in the system ROMs); and the Amiga 2000, with its A2000 board and dual-bus architecture specifically for the support of IBM PC hardware and software.

The new DOS raises some questions about which computer you should buy and for which application interface you should write programs. Since this operating system can run on the 80386 as well as the 80286, it might make sense to purchase a more costly 80386 machine with an eye on the future full-blown 80386 version of the operating system that is sure to come. If you are a programmer working under MS-DOS, you must now choose whether to wait for the next operating system, in the hope that the transition away from the limitations of the old MS-DOS will soon be complete, or use one of the current environments for the applications you create:

- Microsoft Windows.
- DOS 3—this would ensure not only that your programs could run on IBM PCs and PC XTs but also in OS/2's 3.X box.
- The new protected-mode side of OS/2—write your programs for this environment and you jump aboard the train headed for a new, more versatile 80386 operating system. (The Family API construct provides some help in choosing between these last two choices.)

OS/2 is a transitional product. It bridges the 16-bit single-tasking world built on the shoulders of CP/M to the 32-bit multitasking realm of fundamentally different operating systems to come—a transition that might span two years. We hope the flexibility that OS/2's designers have incorporated will allow those of us who will use it to handle this transition smoothly. ■

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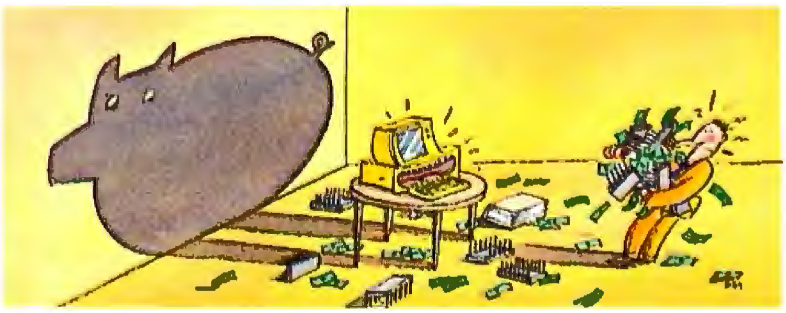

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Inquiry 191

Steve Ciarcia

Part 2: Digitizer/Transmitter

Build a Gray-Scale Video Digitizer

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Last month I described the ImageWise video digitizer's display/receiver section. The display/receiver board accepts binary data from a serial RS-232 port and decodes that data to generate a gray-level display (with 64 levels) on a standard TV monitor. This month I'll complete the project by describing the digitizer/transmitter board (see photo 1) and discussing some possible applications. (Note: Certain portions of this article depend heavily on material presented in last month's Circuit Cellar.)

As I mentioned last month, ImageWise is technically a "field" grabber rather than a "frame" grabber. The digitizer/transmitter board makes no distinction between the two fields in a frame: One is as good as the other. The digitizer/transmitter must decide when a new field is starting, wait until the first active line begins, then begin converting the analog video signal into digital bytes that are stored into the field buffer. Because the video can't be "slowed down," all this must happen when the video occurs rather than when the processor is ready.

You might think that you could locate the start of the first active video line by counting horizontal sync pulses after the conclusion of the vertical sync pulse, but it's not that easy. Some cameras do not produce "standard-width" vertical sync pulses, so counting pulses won't work. Instead, I used an internal timer on the 8031 to provide a fixed delay period (DIP-switch-selectable, either 16- or 20-line times). The first horizontal sync pulse after that delay becomes the first active line to be digitized.

Digitizer/Transmitter Hardware

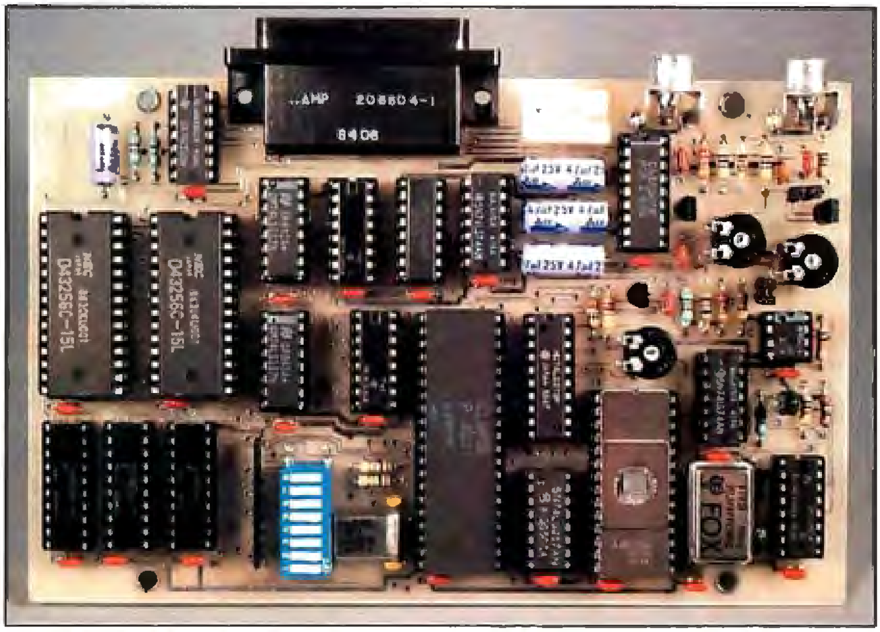
The digitizer/transmitter has two main functions. First, it digitizes the analog video signal; second, it transmits the data to the display/receiver over a serial RS-232 link. Figure 1 shows the digitizer/transmitter circuitry.

The analog circuitry merits a detailed description. Many people who are familiar with the level of integration possible in digital circuitry are appalled at the number of components needed to accomplish even the simplest analog task. The whole mass of circuitry attached to the analog video input performs five functions: termination, clamping, filtering, buffering, and level comparison.

Standard composite video is communicated over coaxial cable with a character-

continued

Photo 1: *The ImageWise digitizer/transmitter in prototype printed circuit form. The digitizer/transmitter board flash-digitizes the video output of a TV camera or other video source (connectors in upper right corner) and converts it to serial data that can be stored and manipulated by a computer or redisplayed on an ImageWise display/receiver board (see last month's Circuit Cellar). The flash A/D converter is the 18-pin chip in the upper right corner; the two 28-pin chips on the left are 64K bytes of static RAM.*



Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P.O. Box 582, Glastonbury, CT 06033.

istic impedance of 75 ohms. To prevent reflections from the end of the cable, it must be terminated in that impedance. The 75-ohm resistor at the video-input connector of the digitizer/transmitter (J3 and J4) accomplishes this goal. A jumper (JP1) disconnects the terminator if you have a terminated device (perhaps a monitor to watch "live" video) connected to the second parallel connector.

Video signals never seem to exhibit "textbook" profiles. Frequently, inexpensive cameras produce video signals with a DC offset that depends on the scene being viewed. The digitizer incorporates clamping circuitry that forces the tips of the sync pulses to 0 volts. This means that the brightest white will be in the area of 1 to 1.4 V (different cameras give different results).

Both color and black-and-white sig-

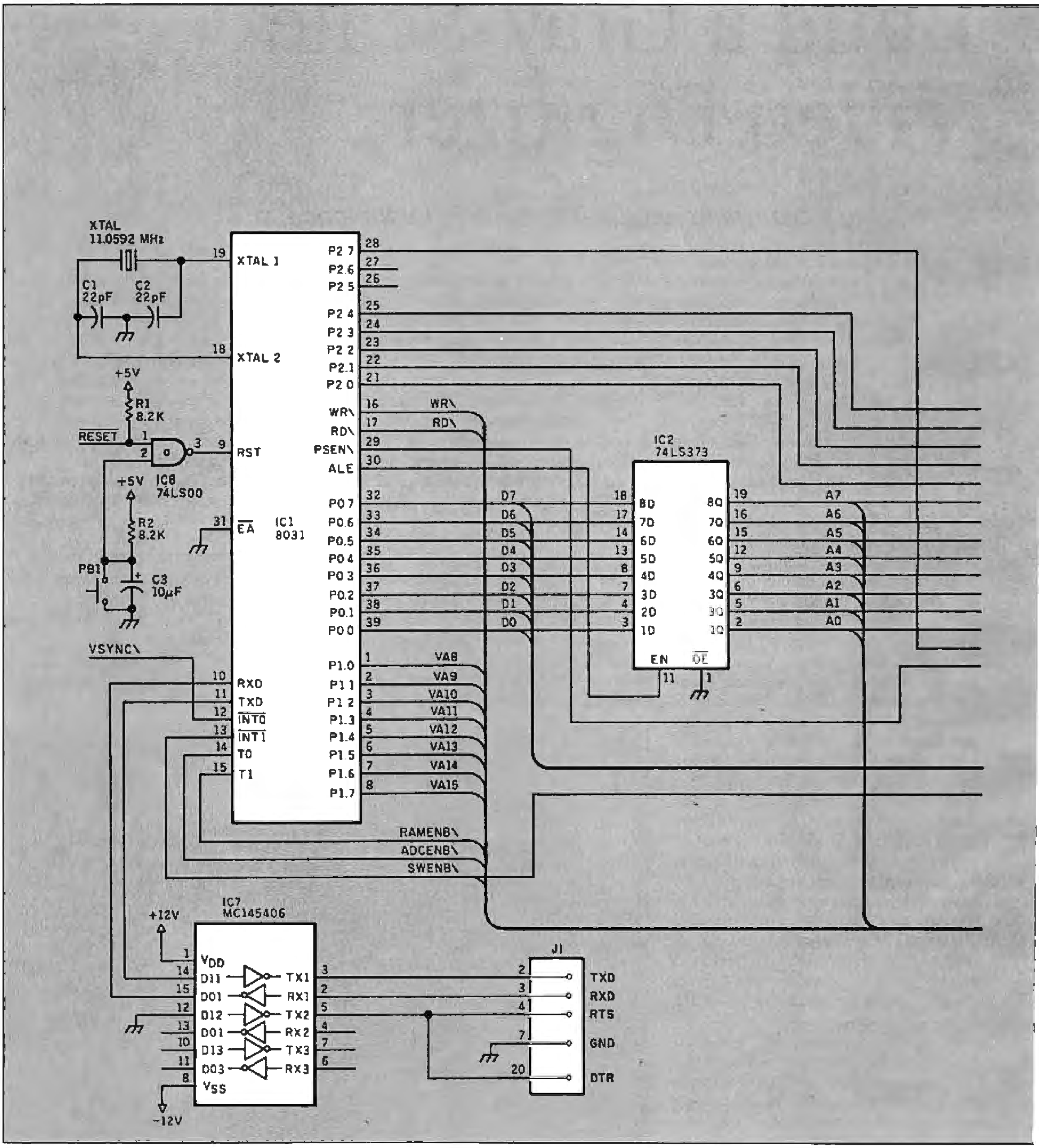
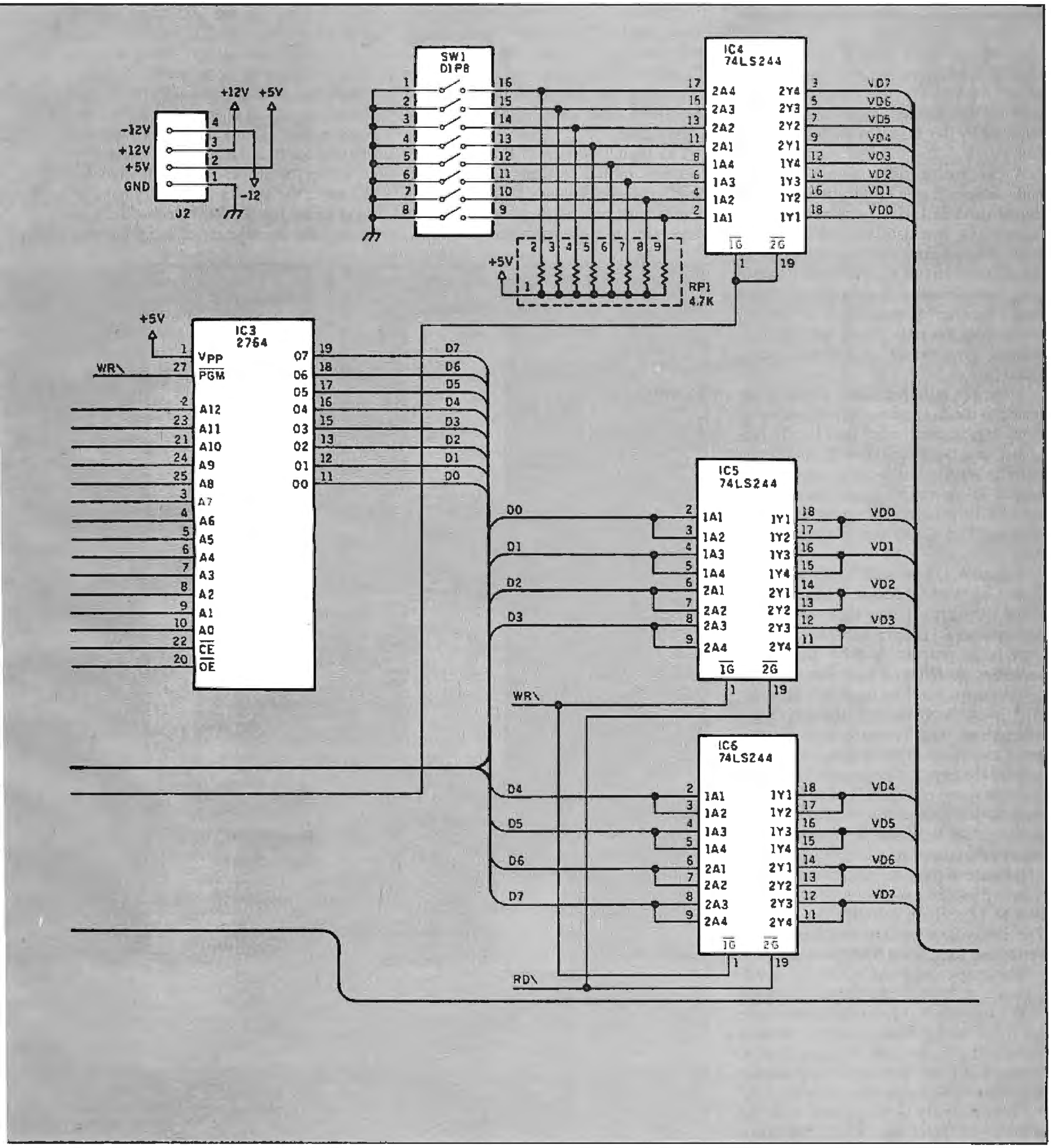


Figure 1: *Schematic for the ImageWise digitizer/transmitter board.*

nals will work with the ImageWise digitizer; however, a color signal contains more information than is necessary. This extra color information is detrimental because it can impart a herringbone pattern on the black-and-white digitized image. I solved this problem by using a filter that removes the frequencies used to encode the color. The remaining signal contains the important intensity voltage that the digitizer measures. You should disconnect this color filter (jumper-selectable JP2) when using a black-and-white camera because the filter doesn't have a sharp cutoff, and it can "soften" the picture by removing some of the finer details. Try it both ways and use the jumper setting that works best for your application.

The 2N4401 transistor serves as a power amplifier to ensure that the re-

continued



A flash A/D converter differs from slower converters in having more internal circuitry.

maining circuitry gets a clean signal without loading the input. Configured as an emitter follower, this transistor circuit supplies the relatively high input current required by the RCA CA3306 flash A/D converter.

A composite video signal contains both video and synchronization information. I used an LM311 comparator configured as a sync detector. Whenever the video drops below 200 millivolts (set by the resistors on pin 3), the LM311 output goes low. Because the clamping circuit forces the sync tips to ground, the LM311 output goes low only during horizontal or vertical sync pulses and never during video data.

Next, the buffered video signal is directed to the A/D converter. As we've already established, video data is extremely fast, and therefore the A/D conversion must be equally fast. I chose the CA3306 6-bit A/D converter for reasons of economy and the existence of readily available sources. The CA3306 is a special flash A/D converter.

A flash A/D converter is different from slower converters because it has more internal circuitry. Rather than use a D/A converter as an integral component in the conversion process, a 6-bit flash A/D converter contains 64 individual voltage comparators, each set to trigger at a specific level. Sophisticated decoding logic determines which comparator is triggered as a result of the applied signal and outputs the appropriate binary code. The ultimate speed of a flash A/D converter is the reaction time of the comparators and the decoding logic and is independent of any system clocks or other timing signals. In the case of the CA3306, its conversion time is 55 to 83 nanoseconds, or 12 million to 18 million samples per second. The ImageWise system requires a converter that samples at 5 megahertz.

The output of the CA3306 is 6 bits within a relative range defined between $+V^{ref}$ and $-V^{ref}$. Most often these limits are +5 V to +8 V and ground. Because we are digitizing only 64 gray levels, however, it is worthwhile to include only the active video range of +0.2 V to +1.5 V. This is easily accomplished with the white ($+V^{ref}$) and black ($-V^{ref}$) trim potentiometers that adjust the CA3306's conversion thresholds so that a bright white will be digitized as hexadecimal 3F and dark black will be hexadecimal 00. I'll describe the adjustment procedure later.

Finally, the delay trim potentiometer (R21) determines the blanking delay from the start of each horizontal sync pulse, which must be adjusted to match the camera. Video conversion begins when the LS221 one-shot times out. It ends exactly 256 pixels later. IC20 is a 20-MHz oscillator that is divided by four to produce the 200-ns clock that drives the pixel counters and supplies the RAM write signal.

The digital portion of the transmitter board is similar to that of the receiver board (see last month's article). Both boards must process the video data in the same way, albeit in opposite directions, so much of the circuitry can be the same.

Without the 8254 counter/timer used on the receiver board, fewer control lines were needed, so I was able to eliminate the 74LS138 decoder. Two 74LS244s isolate the processor data lines from the video data lines, and a third 74LS244 buffers the option switches. An 11.059-MHz crystal lets the 8031 receive and generate standard RS-232 bit rates.

As I mentioned earlier, the input video must be sampled at a rate of 5 MHz, which translates to around 200 ns between samples. A check of the 8031's execution speed shows there is no way that the processor can read the A/D converter, set up the proper address in memory, and store the byte in 200 ns. I chose instead to use the 8031 to select which line is currently being scanned and set up that

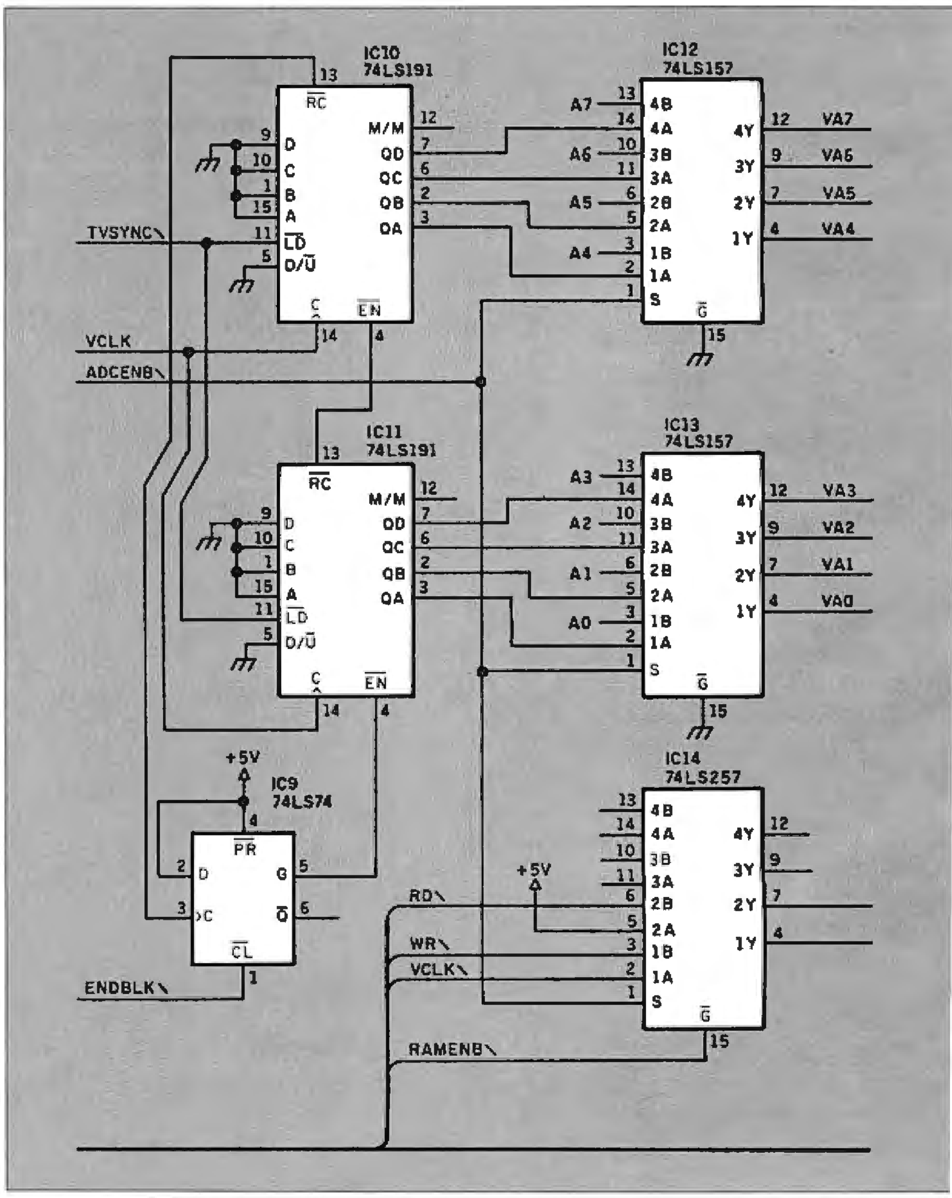


Figure 1: *Continued.*

address in the upper 8 bits of the memory address. Two 74LS191 4-bit counters provide the lower 8 bits automatically. At the start of each scan line, the counters are cleared, and the 8031 sets up the line number. After each pixel has been digitized and stored, the counters increment the address. Since there are about 66 microseconds between the start of each scan line, the processor has plenty of breathing room.

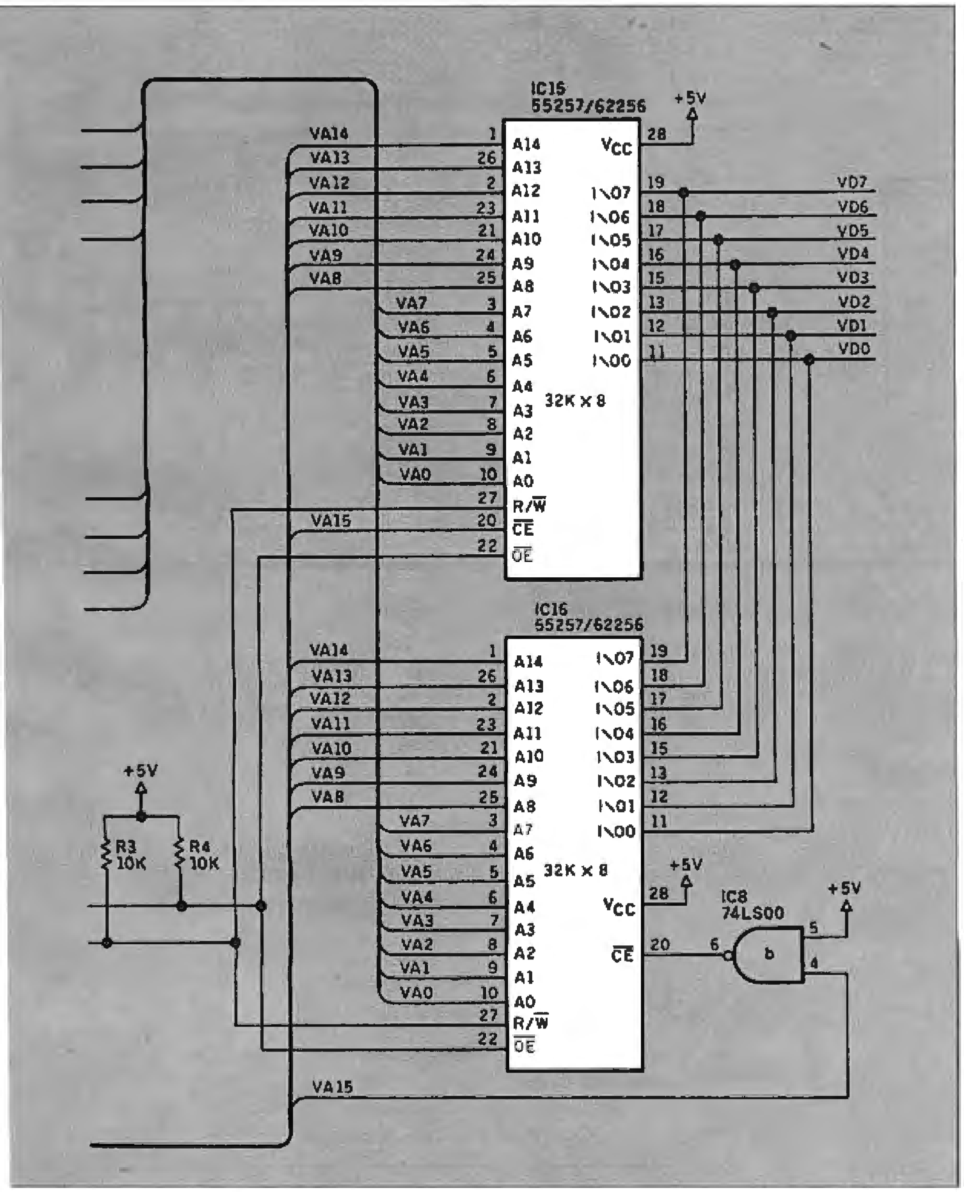
The 74LS257 ensures that we are always writing to the RAM during digitization. Normal processor reads and writes can be performed at any other time for image transmission or other processing.

The Software Connection

The digitizer/transmitter software is a simple loop that captures a video field in the RAM buffer, then compresses and transmits the data via serial RS-232. A DIP-switch setting determines whether the digitizer/transmitter will transmit continuously or wait for an XON from the display/receiver before starting each field (see table 1).

The software begins video data capture when it detects the first vertical sync pulse in a field, as described above. The program then waits for the vertical-blanking delay (determined by using the 8031's internal timer) before enabling the RAMs and the A/D converter. Next, the program counts sync pulses and increments the RAM line address after each pulse. When the buffer is full, it disables the RAMs and the A/D converter to prevent further buffer writes.

The flowchart shown in figure 2 describes the process used to compress the video data in each line. Notice that a unique sync byte designates the start of the field and the line within the field, as well as the end of the video data.



The software captures a video field, then it compresses and transmits the data.

Getting Started

Assuming that you have an ImageWise display/receiver in good working order from last month's project, use the procedure that follows to make your first digitized video connection.

First, connect the camera to the monitor (a coaxial cable without any fancy hardware between) and get a picture that's well-lighted and focused. The adage about "garbage in, garbage out" certainly applies to this operation! Make sure that you've got the monitor terminated in 75 ohms.

Connect the display/receiver to the monitor (remember to disconnect the camera first). Set the DIP switches to 28.8 kilobits per second and no time-out (continuous pictures; see last month's article for a DIP-switch-setting guide for the display/receiver).

Turn the video level (R8) trim potentiometer to midrange and then plug in the power. Do not connect the digitizer/transmitter. The display/receiver will display a diagonal test pattern that includes a gray scale ranging from full white to full black. Adjust the video level trim potentiometer so that the monitor shows the complete range of shades. You may have to tinker with the monitor's hold, brightness, and contrast controls.

Connect the camera to the digitizer/transmitter and install the 75-ohm terminator jumper (JP1). If you're using a color camera, install the color filter jumper (JP2); otherwise, remove it. Set the DIP switches to

28.8k bps
16-line vertical delay
Compression enabled
Ignore +/−1 count changes
Paced mode disabled

Turn the delay (R21), black level (R18), and white level (R14) trim potentiometers to midrange; connect a serial cable between the digitizer/transmitter and display/receiver; and plug in the power. (Note: Set up the serial cable so that pins

continued

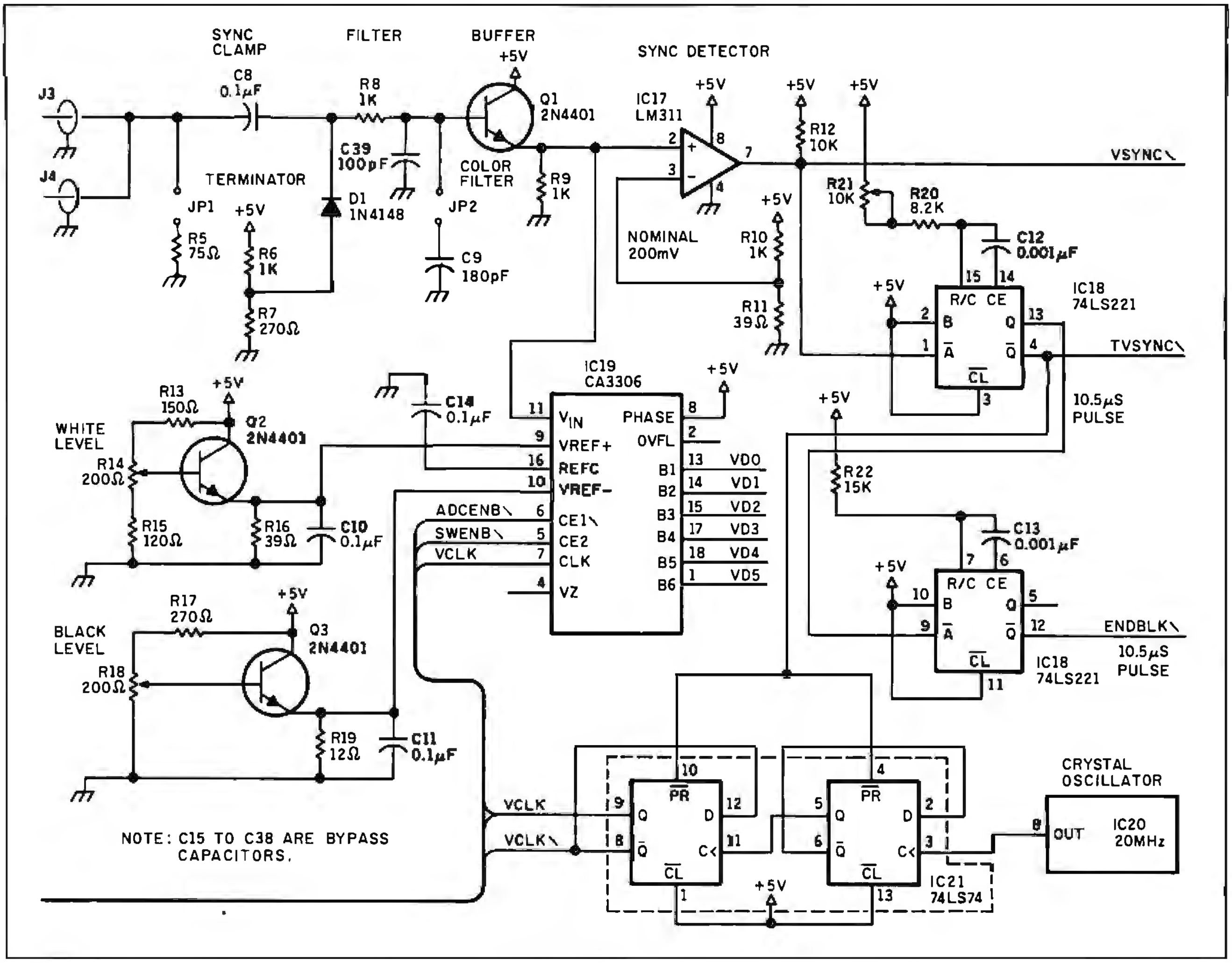


Figure 1: *Continued.*

Table 1: *ImageWise digitizer/transmitter DIP-switch settings. ON and OFF refer to switch positions.*

Switches 1, 2, and 3 select the serial bit rate (must match the receiver's rate).

1	2	3	Serial bit rate (must match receiver rate)
OFF	OFF	OFF	300 bps
OFF	OFF	ON	600 bps
OFF	ON	OFF	1200 bps
OFF	ON	ON	2400 bps
ON	OFF	OFF	9600 bps
ON	OFF	ON	19.2k bps
ON	ON	OFF	28.8k bps
ON	ON	ON	57.6k bps

(Note: 4800 bps was intentionally omitted.)

(Note: Switches 7 and 8 are not used and must be OFF.)

Switch 4 selects the vertical blanking delay from the first vertical sync pulse.

4	Vertical blanking delay
OFF	16 lines (normal)
ON	20 lines (extended)

Switch 5 enables or disables picture compression.

5	Run-length encoding
OFF	disabled (no compression)
ON	enabled (compression)

Switch 6 enables or disables the +/−1 count change compression.

6	Compress +/−1 count changes
OFF	encode (less compression)
ON	ignore (more compression)

2 and 3 are exchanged and pins 5 and 7 are straight through.) You should see the digitized picture appearing on the monitor, painting from top to bottom. After the entire scene is done, another image will be sent. You'll be able to see a horizontal line marking the descending edge of the new picture overlaying the old one.

You should now adjust the black and white trim potentiometers to get the maximum amount of detail in the picture. If the black level is too high (clockwise), dark areas will have little detail, and the whole picture will be dark. If the white level is too low (counterclockwise), the bright areas will suffer, and the picture will be light. You should have a high-contrast scene in front of the camera to make sure you have the right levels. (On the other hand, don't make the black level too low or the white level too high, because that will reduce the number of digital levels in your scene. For example, if your camera's highest voltage is 1.4 V, it does no good to have the white setting at 2.0 V; that 0.6-V difference contains some digital codes that will never be used.)

Adjust the delay trim potentiometer so that the scene is horizontally centered on the monitor. If your monitor has a great deal of overscan, it won't matter too much what the delay setting is. You can also adjust the monitor's horizontal hold knob slightly.

If a line of trash (there's no better way to describe it) appears at the top of the monitor's display, try setting the digitizer/transmitter DIP switch for 20 lines of vertical delay instead of 16. Some cameras produce a few lines of trash at the beginning of the field, and the digitizer/transmitter faithfully digitizes it. If you don't see anything, or if the trash moves to the bottom, leave the DIP switch set for 16 lines.

If you have a monitor connected to the camera (a viewfinder doesn't count), you must make sure that either the monitor is terminated or the termination jumper is installed, but not both or neither. You should terminate the device at the end of the camera cable, not the one in the middle.

You may want to try the filter jumper to see what effect it has on the scene. If you have a color camera, the filter is probably going to be essential; if you have a monochrome camera, you may simply like a softer picture. Do not confuse the effect of the filter jumper with the output of an unfocused camera; make sure the scene is crisp to start with.

Try flipping the digitizer/transmitter switch that ignores +/−1 count changes

continued

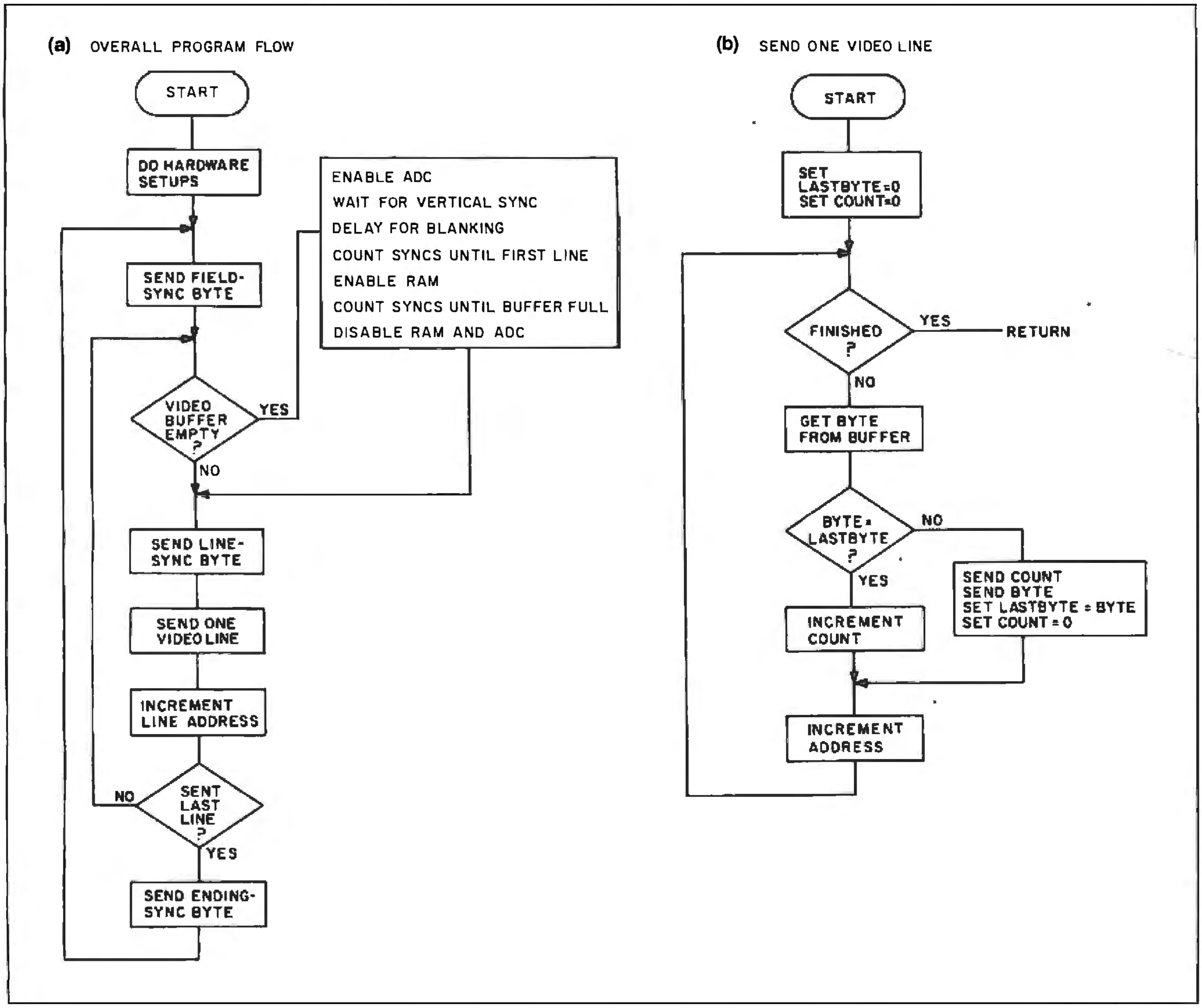


Figure 2: *Flowchart of the digitizer/transmitter software.* **(a)** *This outlines the overall flow of the software.* **(b)** *A flowchart of the routine to transmit a single video line.*

to see what happens to the flat areas in the picture. Disable compression and measure the increase in transmission time.

You can also try changing the bit rates to see which rates work for you. A direct connection can run at 28.8k bps, but for longer wires running through the house, you may need to use a slower rate. At 300 bps you can see the compression working. Remember that the display/receiver will get confused when you change the rate, so you may need to reset the system after changing any DIP-switch settings.

Cheap Buffer Option

I've described how the digitizer/transmitter works with a 64K-byte RAM field buffer made of two 32K-byte static RAM chips. It turns out that you can use an 8K-byte buffer in the digitizer/transmitter. Because the 32K-byte static RAM chips are still rather expensive, I thought it would be worthwhile to reduce the cost for applications that don't need the advantages of the full 64K-byte buffer (Note: The ImageWise kit contains 32K-byte static RAM chips.)

An 8K-byte RAM can hold 32 lines of video (8K bytes divided by 256 bytes per line). The digitizer/transmitter digitizes 32 lines, transmits them, captures another 32 lines, and so on. It keeps track of the last digitized line and starts with the next line for the next group. When it's done, it begins again with the first video line.

Using an 8K-byte RAM is simply a matter of plugging it into the first RAM socket. The 8031 program "feels around" after a reset to determine the RAM size during initialization and uses the proper addresses automatically; no DIP-switch settings are required.

The only difference between using 8K- and 64K-byte RAM buffers occurs when the scene contains moving objects. The 64K-byte buffer can hold a complete frame that is captured in 1/60 second, and it is the only configuration that can legitimately be called a frame grabber. The 8K-byte buffer holds 32 line groups that are digitized several seconds apart, so it's possible to get confused images. If you've ever seen those "panoramic" shots of a line of people with the same person at both ends of the line, you'll recognize the problem right away. But if your application doesn't involve rapid motion, you can save some money on buffer RAMs.

This trick doesn't work in the display/receiver because it must have the entire picture in RAM at all times. Replacing the 64K-byte buffer with an 8K-byte buffer would simply give you 32 lines' worth of picture.

Table 2: *Hayes Smartmodem DIP-switch settings for use with the ImageWise system.*

Switch	Setting	Description
1	DOWN	Smartmodem DTR input on pin 20 is forced active.
2	UP	Don't care, UP for English responses to commands.
3	UP	Suppress responses to commands.
4	DOWN	Do not echo characters.
5	UP	Smartmodem will auto-answer on first ring.
6	UP	Don't care, UP for CD when carrier detected.
7	UP	Single-line phone connection.
8	UP	Disable Smartmodem command recognition.

Photo 2: *The ImageWise digitizer captures a high-quality gray-scale image that can be used in areas like security and pattern recognition. In the surveillance application shown here, an empty room is entered, used, and then exited. To save space in this presentation, all four scenes are displayed on a GT180 (in 16-level gray scale).*

Using a Modem

Because both the digitizer/transmitter and the display/receiver use a two-wire serial interface and XON/XOFFs to control data flow, they can be connected through a pair of modems as well as by direct wiring. The only problem is the low data rate that modems can handle. This is an ideal application for 2400- and 9600-bps modems.

One application might be to have the ImageWise digitizer/transmitter wait for a phone call, auto-answer, and then transmit the picture it sees at that remote location. Voilà, video security system or videotelephone. The switch settings for a Hayes Smartmodem 1200 are shown in table 2. Note that you can use other modems as long as they have auto-answer capabilities.

Using ImageWise

The ImageWise system can be used as a digitizer and display board pair or as individual components of some higher-function system. Used as a pair, "teleimaging" becomes a reality. By adding the sense of sight to our ordinary audio communication, we add a new level of communication and understanding. No longer does the field engineer have to be frustrated trying to justify replacement rather than repair of an expensive electrical component. A quick digitized image flashed back to the head office verifies significant fire damage and gets the proper authorization for immediate action.

The key factor in this new level of communication is the old saying that "seeing is believing." Consider another example: You are a consultant at a customer's site, and some question arises as to the actual wording and the date of a revision note on an important schematic. Rather than waste a day with express delivery, you can call your office and have them transmit a digitized image of the portion of the schematic in question complete with the authorization signature and date as they appear.

ImageWise has an infinite number of stand-alone uses. It can be used to instantly communicate fingerprints and ID photos, monitor traffic at remote intersections, monitor remote security risk zones (see photo 2) via auto-answer modems, aid in conducting company-wide lectures (standard audio teleconference with pictures of the blackboard periodically sent to all locations; see photo 3), or send x-rays and CAT scan pictures to medical personnel for corroborating diagnosis.

Some of these uses might seem ambitious for ImageWise, but similar more expensive units are already being applied in these areas. My immediate application may seem mediocre by comparison. Recently, I've been spending time out of the Circuit Cellar at an office across town. Since I already had a TV camera in my driveway (no windows in the cellar, remember), I simply attached it to the digitizer/transmitter and a 2400-bps auto-answer modem. Now I can call the house and get the latest snapshot or simply leave it on all the time as a real-time display of all the activity around the house (see photo 4). (I have four telephone lines; I can call the Home Control System on its own line if I want to have some real fun with someone like a delivery man. These guys all think my house is haunted.)

You'll note that I have described ImageWise only in terms of a 256- by 256- by 6-bit digitizer. Because I intended to use it with a modem, I felt the need to increase the picture-transmission speed. One way is to reduce the resolution to 128 by 121 or 64 by 61 bits. Even though such resolutions produce grainy images, they are still quite recognizable, especially if they are of familiar faces or geography (the recently advertised Mitsubishi video telephone has a 94- by 94- by 4-bit resolution by comparison). The 64- by 61-bit image is transmitted eight times faster than a 256- by 256-bit image and is suitable for monitoring gross changes in a driveway scene when a car or a person approaches.

When something appears, I can immediately change the DIP switches on the display board for a higher resolution and trigger another picture while the form is still in view. (The frame is grabbed instantly and is independent of the transmission time.) The picture-repeat rate and resolution, remember, are commanded from the receiver and not fixed by the transmitter. The interaction is completely dynamic. My next activity is to connect the ImageWise digitizer to a computer and let it decide what's happening for itself and make all the decisions.

Fortunately, this is as easily said as done. Probably the most significant feature of ImageWise is that it is computer-nonspecific. It is a serial RS-232 I/O device that does not depend on any computer-specific bus. The ImageWise digitizer/transmitter's serial port can be connected to any personal computer. The computer can receive image data and store it on disk or send it to a similarly connected display/receiver board. So far we've written the software for my SB180 and the IBM PC. Others will follow.

Experimenters

While printed circuit boards and kits are available for the ImageWise system, I encourage you to build your own. If you don't mind doing a little work, I will support your efforts as usual. A hexadecimal file of the executable code for the 8031 digitizer and display system EPROMs, sample picture files, and the Turbo Pascal

continued

Photo 3: *This is how a picture of me standing in front of a blackboard in Connecticut would be received by an ImageWise display/receiver board in California. A video printer like the Mitsubishi unit shown here can save the current scene while another is being transmitted.*

Photo 4: *The equipment counter in the Circuit Cellar where I took most of the photos with the setup you see. The interesting point to realize here is that this picture is completely digitized. A video camera (out of view) is pointed at the two stacked monochrome monitors and the film camera. The monitor on the bottom displays the picture as it is produced by the video camera and input to the digitizer/transmitter board. The display on top shows the output of the display/receiver board after it receives the data from the digitizer. It is the object of view by the film camera. This picture is the screen of the top monitor.*

code for storing images on an IBM PC are available for downloading from my bulletin board at (203) 871-1988 (similar code written for the SB180 in machine language is also available). Alternatively, you can send me a preformatted IBM PC or SB180 disk with return postage, and I'll put all the files on it for you (the hexadecimal file could be used with my serial EPROM programmer, for example). Of course, this free software is limited to noncommercial personal use.

Next Month

Once you've got a picture in digital format, you can write programs that perform magic tricks with it (hardware people like to think that way). By manipulating the binary data making up the picture, you can transform it into another picture that may be more meaningful. You can even combine two pictures to find differences—this is called image processing.

Now that we have the ImageWise digitizer, we have the means to perform some real experiments. I know many tutorial articles on image processing have been published, but the true Circuit Cellar creed is to build it yourself. Using ImageWise, next month I'll demonstrate how the basics of picture comparison, enhancement, and other image-processing fundamentals can be done for real. Finally, in another conversion of tutorial to example for August, I will demonstrate the process of colorizing the 64-level grayscale ImageWise picture. ■

Special thanks to Ed Nisley for his expert collaboration on this project.

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 Company, 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.

The following items are available from

CCI
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1. ImageWise digitizer/transmitter board experimenter's kit. Contains digitizer/transmitter printed circuit board, 11.05-MHz crystal, programmed 2764 EPROM with transmitter software, and CA3306 flash A/D converter and manual with complete parts list.
DT01-EXP $99

2. ImageWise display/receiver board experimenter's kit. Contains gray-scale display/receiver printed circuit board, 11.05-MHz crystal, programmed 2764 EPROM with receiver software, Telmos 1852 video D/A converter, manual with complete parts list, and an IBM PC 2.0 disk containing sample digitized images and test patterns.
DR01-EXP $99
DT01-EXP and DR01-EXP together $179

3. ImageWise digitizer/transmitter full kit. Contains all digitizer/transmitter components, including printed circuit board, 64K bytes of static RAM, IC sockets, crystals, programmed 2764, CA3306 flash A/D converter, manual, and IBM PC 2.0 disk containing utility routines for storing and displaying (dot-dithered, not gray scale) and downloading image files using an IBM PC. Does not include power supply or case.
DT01-KIT $249

4. ImageWise display/receiver full kit. Contains all gray-scale display/receiver components, including printed circuit board, 64K bytes of static RAM, IC sockets, crystals, programmed 2764, Telmos 1852 video D/A converter, manual, and an IBM PC 2.0 disk containing sample digitized images and test patterns. Does not include case or power supply.
DR01-KIT $249
DT01-KIT and DR01-KIT together $489

ImageWise is also available assembled. Call CCI for source and availability of assembled boards and complete systems, black-and-white TV cameras, 32K-byte static RAM chips, and power supplies. Software utilities are also available in SB180 format.

All payments should be made in U.S. dollars by check, money order, MasterCard, or Visa. Surface delivery (U.S. and Canada only): add $3 for U.S., $6 for Canada. For delivery to Europe via U.S. airmail, add $10. Three-day air freight delivery: add $8 for U.S. (UPS Blue), $25 for Canada (Purolator overnight), $45 for Europe (Federal Express), or $60 for Asia and elsewhere in the world (Federal Express). Shipping costs are the same for one or two units.

There is an on-line Circuit Cellar bulletin board system that supports past and present projects. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300/1200/2400-bps BBS is on-line 24 hours a day at (203) 871-1988.

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AW . . .

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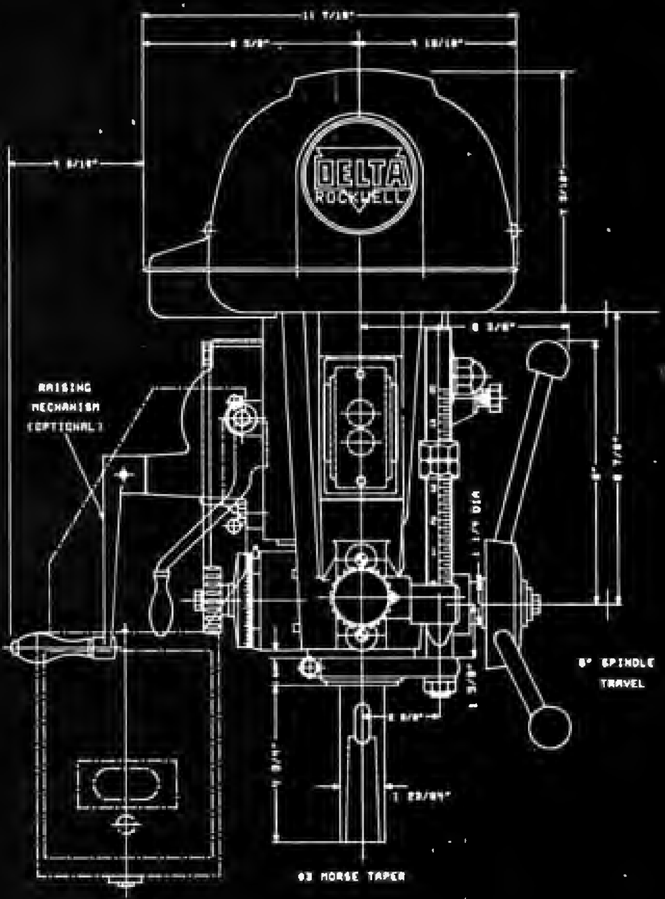

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Paul D. Bourke

A Contouring Subroutine

Represent any three-dimensional surface on a flat plane with this BASIC program

Contouring is a way of profiling a three-dimensional surface using a two-dimensional medium such as paper or a computer screen. Two everyday applications of contouring are the display of elevations on topological maps and air pressure zones on weather maps.

Generally, given a function F of two variables x and y, the contour of F at c is the set of all (x,y) such that $F(x,y) = c$. Except when $F(c)$ is a local minimum or maximum (the top of a hill or the bottom of a valley), the points satisfying $F(x,y) = c$ define one or more contour lines. Letting c take on various values through the range of F produces a contour map like those shown in figure 1.

Algorithms that do computer contouring typically involve advanced mathematical techniques. As a result, the programs implementing these methods are usually computation-intensive. In contrast, the technique presented in this article is easy to implement, very reliable, and does not require sophisticated programming techniques or high-level mathematics. I have adapted the present BASIC version from a FORTRAN subroutine written in 1983 by Dr. M. D. Jones for a PDP-11 at the physics department at Auckland University in New Zealand.

The subroutine, called `CONREC`, takes as its input a set of three-dimensional data points (x_i, y_i, z_i) and a list of contour levels that usually spans the range of z_i. The size of the intervals between contour levels determines how precisely the contour map will represent a given set of

continued

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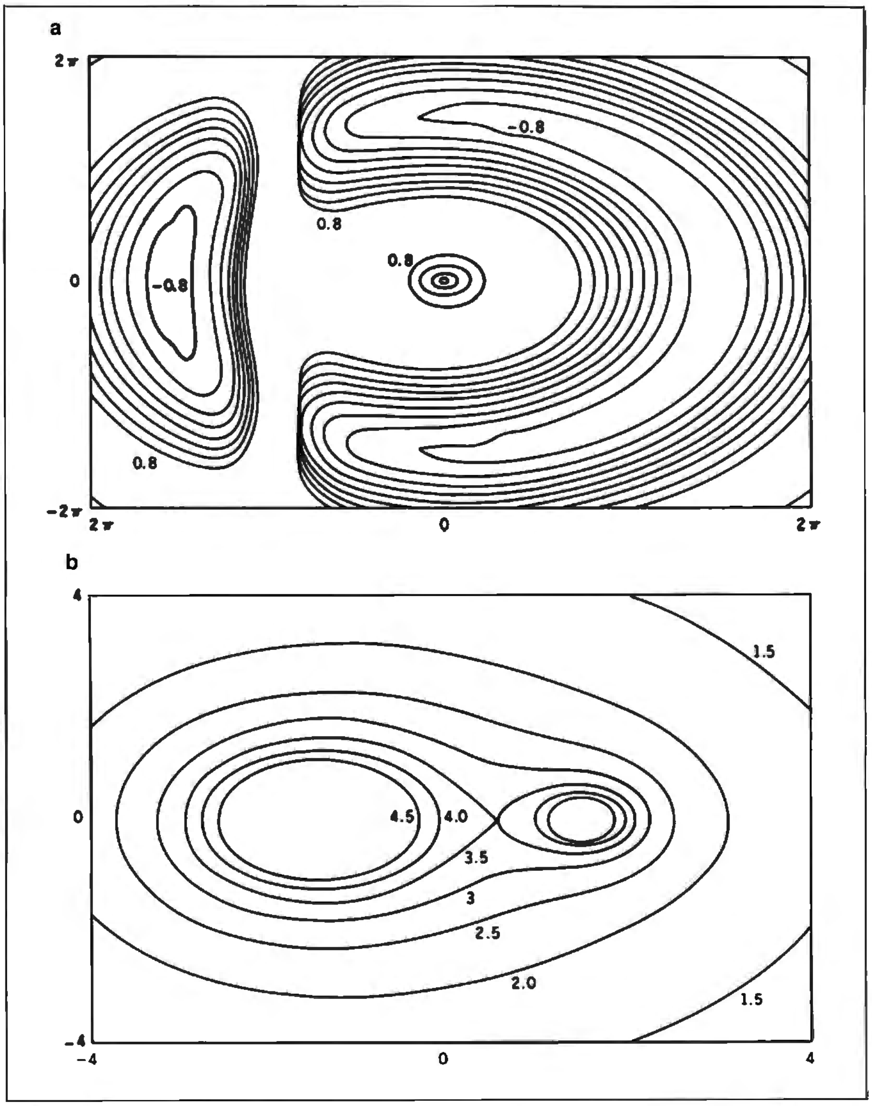

Figure 1: *Contour maps of a mathematical function (a) described in the text and of equipotential fields (b) around two charge particles.*

The program allows for non-square grids and for uneven spacing between coordinates.

data in any specific instance.

CONREC allows for nonsquare grids in which the number of x coordinates is not equal to the number of y coordinates, and for uneven spacing between coordinates. For instance, x coordinates used in a data collection can range from 15 to 36 at intervals of 3, 3, 3, 1, 1, 1, 3, 3, 3 while y coordinates range from 1 to 100 at uniform intervals of 1.

The output from CONREC is a sequence of line segments (x_1,y_1)-(x_2,y_2) and corresponding contour levels. This data is then sent to a plotting subroutine to be drawn by an output device. In the simplest case, the output device draws the line segments on a standard x,y coordinate grid, ignoring the contour-level value. In a color system, the color of the line might be keyed to its contour value. In a monochrome system, you can draw the contour lines with differing line styles or label them according to their contour level (but the latter takes some extra work to avoid cluttering up the map with redundant labels).

The Algorithm

CONREC treats the data in groups of four contiguous points. Ignoring the z coordinates, each quadruplet forms a rectangle whose vertices are (x_i, y_j), (x_{i+1}, y_j), (x_i, y_{j+1}), (x_{i+1}, y_{j+1}). Each rectangle is divided into four triangular regions by cutting along the diagonals, as shown in figure 2a. The program interpolates x and y coordinates of the centerpoint C from the four vertices and estimates the z coordinate as the average of the four vertices' z coordinates.

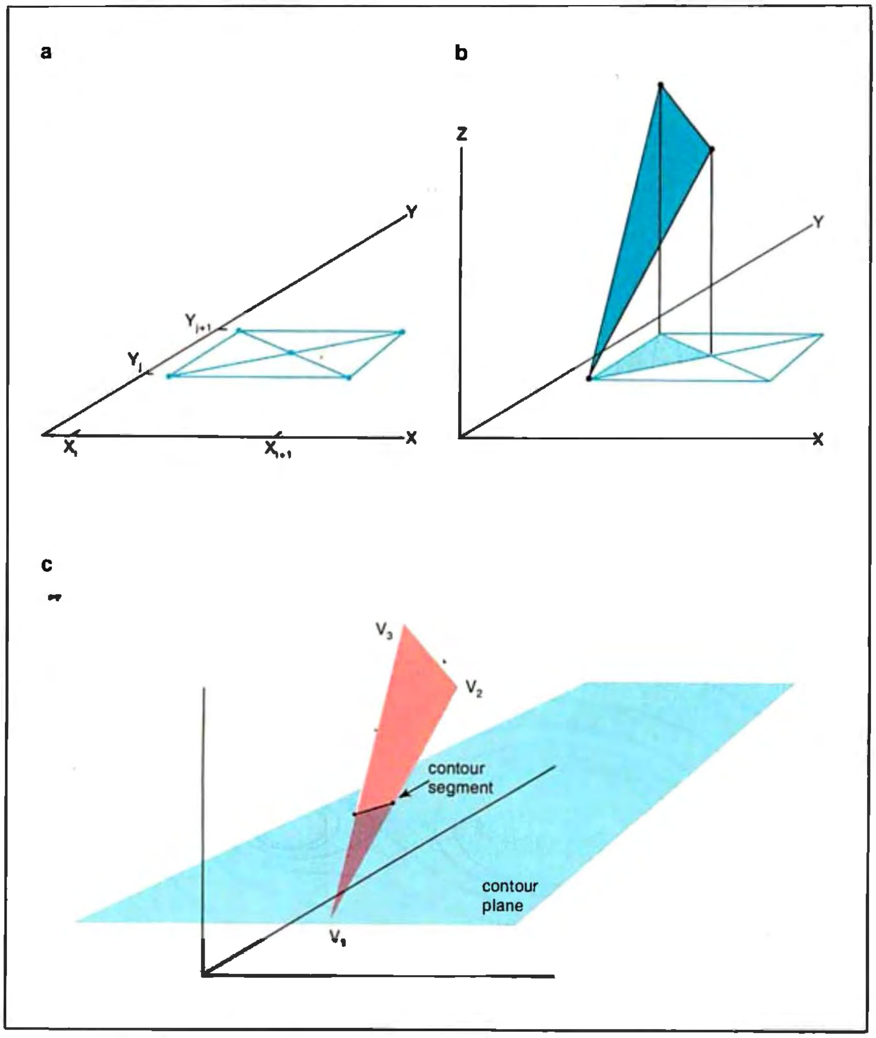

Figure 2: *The data points are analyzed in groups of four contiguous points. These rectangles are divided into triangles (a). The centerpoint C's coordinates are interpolated, giving three triangles in three-dimensional space (b shows one of them). The intersection of these triangles with the contour plane determines the location of the contour segments (c).*

Thus, we have four triangles in three-dimensional space. (Figure 2b illustrates one of them.) The actual work of generating the contour lines is done with respect to these triangles. For each triangle, CONREC finds its intersection with the contour plane. Elementary geometry tells us that two flat planes intersect in a line, a point, a plane, or the null set (no intersection). When the intersection is a line (as in figure 2c), CONREC generates a contour segment along that line. In the other cases (point, plane, or null set), it draws no contour segment. When plotted, the individual contour segments make up the contour lines.

CONREC uses a classification scheme to determine the nature of the intersection and what action is needed. The classification depends on whether the vertices are above, on, or below the contour plane. Only ten cases are possible, and these are grouped into six categories, as shown in figure 3 and enumerated in table 1.

Only the intersections of type I, II, and III result in contour line segments. The start and end points of type I segments correspond to two of the triangle's vertices. For type II segments, one of the endpoints is known and the other is interpolated. For type III segments, both endpoints are interpolated.

As an example, consider the triangle with vertices v_1, v_2, v_3 whose z coordinates (or "heights") are 0, 2, and 3, respectively (see figure 2c). Suppose you want to draw a contour line at height 1. Referring to table 1, you see that the intersection of the triangle with the contour plane is type III—a line through two sides of the triangle. Contour-level 1 intersects the line segment v_1v_2 at its midpoint and intersects v_1v_3 one-third of the way from v_1.

When all the contour levels have been drawn for a rectangle, CONREC moves to the next rectangle. The process is repeated until all the rectangles have been checked. The rectangles are examined from the top down and from left to right.

CONREC reads the entire array into memory. However, the contouring algorithm does not require access to all the data points at once; only four points are referenced at a time. This makes the algorithm suitable for processing large data sets that would exceed the amount of memory available for array storage. However, CONREC would need some minor modifications to do so.

The program must calculate most of the contour segment endpoints twice—

continued

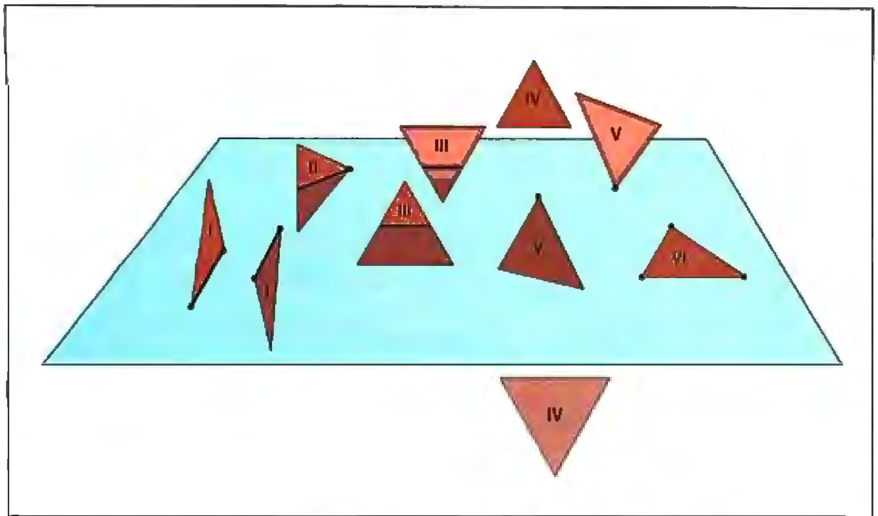

Figure 3: *Six types of intersections between triangles and the contour plane; only three types result in contour line segments.*

Table 1: *Classification scheme for the intersections between a triangle and the contour plane.*

Type	Intersection of triangle and the contour plane	Point locations with respect to the contour plane
I	Line through one side of the triangle	1 above, 2 on plane 1 below, 2 on plane
II	Line bisecting the triangle through one vertex	1 above, 1 below, 1 on plane
III	Line bisecting the triangle through two sides	1 above, 2 below plane 2 above, 1 below plane
IV	No intersection	3 above plane 3 below plane
V	Point intersection	2 above, 1 on plane 2 below, 1 on plane
VI	Plane intersection	3 on plane

Listing 1: *The* CONREC *subroutine, written in Microsoft QuickBASIC.*

```
REM    Input variables to CONREC
REM    d(0:iub,0:jub)     'Matrix for the data surface
REM    iub, jub    'Index bounds of the data array
REM    x(0:iub)     'Data array for column coordinates
REM    y(0:jub)     'Data array for row coordinates
REM    nc     'Number of contour levels
REM    z(0:nc-1)     'Contour levels in increasing order
REM    VECOUT    'An external subroutine to plot the contour lines
REM    False and true Boolean values
REM
conrec:
REM    Local declarations for CONREC
DIM h(4)     'Relative heights of the box above contour
DIM ish(4)     'Sign of h( )
DIM xh(4)     'x coordinates of box
DIM yh(4)     'y coordinates of box
DIM im(3)     'Mapping from vertex numbers to x offsets
im(0)=0 : im(1)=1 : im(2)=1 : im(3)=0
DIM jm(3)     'Mapping from vertex numbers to y offsets
jm(0)=0 : jm(1)=0 : jm(2)=1 : jm(3)=1
```

continued

Listing 1: *continued.*

```
DIM castab(2,2,2)     'Case switch table
DATA 0, 0, 8, 0, 2, 5, 7, 6, 9, 0, 3, 4, 1, 3, 1, 4, 3, 0, 9, 6, 7, 5, 2, 0, 8, 0, 0
FOR k=0 TO 2  :  FOR j=0 TO 2  :  FOR i=0 TO 2
   READ castab(k,j,i)
NEXT i  :  NEXT j  :  NEXT k
REM
REM    Check the input parameters for validity
prmerr=false
IF (iub=<0 OR jub=<0) THEN prmerr=true
IF (nc<=0) THEN prmerr=true
FOR k=1 TO nc-1  :  IF (z(k)<=z(k-1)) THEN prmerr=true  :  NEXT k
IF (prmerr) THEN msg$=''Error in input parameters''  :  RETURN
REM
REM    Scan the array, top down, left to right
REM
FOR j=jub-1 TO 0 STEP -1
FOR i=0 TO iub-1
REM    Find the lowest vertex
IF (d(i,j)<d(i,j+1)) THEN dmin=d(i,j) ELSE dmin=d(i,j+1)
IF (d(i+1,j)<dmin) THEN dmin=d(i+1,j)
IF (d(i+1,j+1)<dmin) THEN dmin=d(i+1,j+1)
REM    Find the highest vertex
IF (d(i,j)>d(i,j+1)) THEN dmax=d(i,j) ELSE dmax=d(i,j+1)
IF (d(i+1,j)>dmax) THEN dmax=d(i+1,j)
IF (d(i+1,j+1)>dmax) THEN dmax=d(i+1,j+1)
IF (dmax<z(0) OR dmin>z(nc-1)) THEN GOTO noneinbox
REM    Draw each contour within this box
FOR k=0 TO nc-1
IF ((z(k)<dmin) OR (z(k)>dmax)) THEN GOTO noneintri
FOR m=4 TO 0 STEP -1
IF m>0 THEN
h(m)=d(i+im(m-1),j+jm(m-1))-z(k)  :  xh(m)=x(i+im(m-1))  :  yh(m)=y(j+jm(m-1))
IF m=0 THEN
h(0)=(h(1)+h(2)+h(3)+h(4))/4  :  xh(0)=(x(i)+x(i+1))/2  :  yh(0)=(y(j)+y(j+1))/2
IF h(m)>0 THEN ish(m)=2  :  ELSE IF (h(m)<0) THEN ish(m)=0  :  ELSE ish(m)=1
NEXT m
REM    Scan each triangle in the box
FOR m=1 TO 4
m1=m  :  m2=0  :  m3=m+1  :  IF (m3=5) THEN m3=1
case=CINT(castab(ish(m1),ish(m2),ish(m3)))
IF (case=0) THEN GOTO case0
ON case GOTO case1, case2, case3, case4, case5, case6, case7, case8, case9
REM    Line between vertices m1 and m2
case1: x1=xh(m1)  :  y1=yh(m1)  :  x2=xh(m2)  :  y2=yh(m2)
     GOTO drawit
REM    Line between vertices m2 and m3
case2: x1=xh(m2)  :  y1=yh(m2)  :  x2=xh(m3)  :  y2=yh(m3)
     GOTO drawit
REM    Line between vertices m3 and m1
case3: x1=xh(m3)  :  y1=yh(m3)  :  x2=xh(m1)  :  y2=yh(m1)
     GOTO drawit
REM    Line between vertex m1 and side m2-m3
case4: x1=xh(m1)  :  y1=yh(m1)
     x2=(h(m3)*xh(m2)-h(m2)*xh(m3))/(h(m3)-h(m2))
     y2=(h(m3)*yh(m2)-h(m2)*yh(m3))/(h(m3)-h(m2))
     GOTO drawit
REM    Line between vertex m2 and side m3-m1
case5: x1=xh(m2)  :  y1=yh(m2)
     x2=(h(m1)*xh(m3)-h(m3)*xh(m1))/(h(m1)-h(m3))
     y2=(h(m1)*yh(m3)-h(m3)*yh(m1))/(h(m1)-h(m3))
     GOTO drawit
REM    Line between vertex m3 and side m1-m2
case6: x1=xh(m3)  :  y1=yh(m3)
     x2=(h(m2)*xh(m1)-h(m1)*xh(m2))/(h(m2)-h(m1))
     y2=(h(m2)*yh(m1)-h(m1)*yh(m2))/(h(m2)-h(m1))
     GOTO drawit
```

continued

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Listing 1: *Continued.*

```
REM   Line between sides m1-m2 and m2-m3
case7: x1=(h(m2)*xh(m1)-h(m1)*xh(m2))/(h(m2)-h(m1))
       y1=(h(m2)*yh(m1)-h(m1)*yh(m2))/(h(m2)-h(m1))
       x2=(h(m3)*xh(m2)-h(m2)*xh(m3))/(h(m3)-h(m2))
       y2=(h(m3)*yh(m2)-h(m2)*yh(m3))/(h(m3)-h(m2))
       GOTO drawit
REM   Line between sides m2-m3 and m3-m1
case8: x1=(h(m3)*xh(m2)-h(m2)*xh(m3))/(h(m3)-h(m2))
       y1=(h(m3)*yh(m2)-h(m2)*yh(m3))/(h(m3)-h(m2))
       x2=(h(m1)*xh(m3)-h(m3)*xh(m1))/(h(m1)-h(m3))
       y2=(h(m1)*yh(m3)-h(m3)*yh(m1))/(h(m1)-h(m3))
       GOTO drawit
REM   Line between sides m3-m1 and m1-m2
case9: x1=(h(m1)*xh(m3)-h(m3)*xh(m1))/(h(m1)-h(m3))
       y1=(h(m1)*yh(m3)-h(m3)*yh(m1))/(h(m1)-h(m3))
       x2=(h(m2)*xh(m1)-h(m1)*xh(m2))/(h(m2)-h(m1))
       y2=(h(m2)*yh(m1)-h(m1)*yh(m2))/(h(m2)-h(m1))
drawit:
       CALL vecout(x1,y1,x2,y2,z(k))
case0: NEXT m
noneintri: NEXT k
noneinbox: NEXT i ; NEXT j
RETURN
```

Listing 2: *A QuickBASIC example program to draw the contour map shown in figure 1a.*

```
CLS: PRINT ''CONREC example. Contour the function''
PRINT: PRINT ''f(x,y)=sin((x^2+y^2)^.5) + ((x-c)^2+y^2)^-.5''
PRINT: PRINT ''letting x and y range from -2 pi to +2 pi.''
PRINT ''Building the data set now. Please wait.''
OPTION BASE 0    'Lower bound of zero for all array indices
pi=3.141592654#
true=-1 : false=0
ilength=319 : jlength=199    'Dimensions of the output contour plot axes
(full screen in CGA mode)
imin=0 : jmin=199    'Coordinates of the left bottom corner
iub=30 : jub=30 : nc=10    'Number of grid intervals and contour levels
DIM d(iub,jub),x(iub),y(jub)    'Data array
DIM z(nc-1)    'Contour array

REM   Define the function and the coordinates
FOR i=0 TO iub    'Check at all x-grid levels
   ix=2*pi*(2*i-iub)/iub    'ix ranges from -2 pi to + 2 pi
   FOR j=0 TO jub    'Check at all y-grid levels
      jy=2*pi*(2*j-jub)/jub    'jy ranges from -2 pi to + 2 pi
      r=SQR(ix^2+jy^2)
      d(i,j)=SIN(r)+.5/SQR((ix+3.05)^2+iy^2)
   NEXT j
   x(i)=i*ilength/iub+imin    'Scale x(i) to span plot area
NEXT i
FOR j=0 TO jub
   y(j)=jmin-j*jlength/jub    'Scale y(i) to span plot area
NEXT j
FOR i=0 TO nc-1
   z(i)=(i-5)/5    'Contour levels at -1,-.8,...,1
NEXT i

CLS: SCREEN 1,0    'CGA screen 320 by 200
LINE (imin,jmin-jlength)-(imin+ilength,jmin),,b    'Use a box for axes
GOSUB conrec
IF NOT(prmerr) THEN PRINT : PRINT : PRINT msg$;
WHILE LEN(INKEY$)=0 : WEND    'Any key to stop
END
```

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once for each of the two triangles that share a common boundary. For instance, in figure 2c, both endpoints of the contour segment will have to be calculated again when the program looks for the intersection of the two adjacent triangles and the contour plane.

The program could be speeded up if these contour segment endpoints were remembered rather than recalculated each time. However, this would complicate the program logic and make the listing longer. It would also require that more than four points be kept in memory at a time.

Notes on the Listings

The CONREC subroutine (see listing 1) is written in Microsoft QuickBASIC 2.0. With minor changes to the screen output commands, it will run under Microsoft BASIC for the Macintosh. Older versions of Microsoft BASIC will require you to make a few other minor changes.

[Editor's note: *Listings 1.BAS through 4.BAS are available on disk, in print and on BIX; see the insert card prior to page 321. Listings are also available on BYTEnet; see page 4.*]

The input parameters to CONREC are:

- The number of discrete intervals in the horizontal and vertical measurement grids, stored in iub and jub.
- The number of contouring levels, stored in nc.
- A one-dimensional array z(0:nc-1) containing the contour levels in increasing order.
- A two-dimensional array d(0:iub, 0:jub) containing the z values computed or measured at each (x,y) pair.
- Two one-dimensional arrays, x(0:iub) and y(0:jub), containing the actual horizontal and vertical coordinates of each sample point, making it possible to use data collected on a nonsquare grid, or data with varying grid intervals.

For the sake of example, I have supplied two sample programs (see listings 2 and 3) that supply CONREC with a set of data points, as well as a subroutine called VECOUT for drawing the contour map on a computer screen (see listing 4).

Example 1 uses CONREC to draw the contour of the mathematical function

$$f(x,y) = \sin((x^2 + y^2)^{1/2}) + ((x - c)^2 + y^2)^{-1/2}.$$

The contour map of the function is shown in figure 1a.

Example 2 is taken from physics. Given two electrical charges q_1 and q_2, located along the x axis at $-c$ and $+c$, the electrical potential at a point (x,y) is given by the equation:

$$V(x,y) = k\left(\frac{q_1}{r_1} - \frac{q_2}{r_2}\right)$$

where k is a constant and r_1 and r_2 are the distances of (x,y) from q_1 and q_2. Contouring this function generates a map of equipotential surfaces emanating from two charge particles (see figure 1b). A similar function graphs the gravitational fields around two masses.

To use CONREC for your own projects, you need to write a main program similar to those in listings 2 and 3 as well as a VECOUT subroutine to handle the output to your plotter device (similar to the one in listing 4). Append these subroutines to the main program, and you are ready to begin making your own contour maps.

Contouring as implemented in the CONREC subroutine gives you a fast way to see the shape of a function or a set of data points. Although not as intuitive as three-dimensional representations, contour maps avoid the problems of hidden line removal and three-dimensional projections onto two-dimensional surfaces. ■

Listing 3: *A QuickBASIC example program to draw the contour map shown in figure 1b.*

```
CLS: PRINT ''CONREC example. Graph the equipotential lines''
print ''around two charged particles by contouring the function''
print: print ''V(x,y)=q1/r1 - q2/r2''
print ''letting x and y range from -4 to 4.''
OPTION BASE 0    'Lower bound of zero for all array indices
pi=3.141592654#
true=-1 : false=0
ilength=319 : jlength=199    'Dimensions of the output contour plot axes
(full screen in CGA mode)
imin=0 : jmin=199    'Coordinates of the left bottom corner
iub=30 : jub=30 : nc=8    'Number of grid intervals and contour levels
DIM d(iub,jub),x(iub),y(jub)    'Data array
DIM z(nc-1)    'Contour array
REM
REM    Define the function and the coordinates
a=1.5 : q1=1 : q2=-4    'Charge q1 is at -a; q2 is at +a
FOR i=0 TO iub
   ix=4*(2*i-iub)/iub    'Range from -4 to 4
   FOR j=0 TO jub
      jy=4*(2*j-jub)/jub    'Range from -4 to 4
      r1=SQR((ix-a)^2+jy^2)
      r2=SQR((ix+a)^2+jy^2)
      d(i,j)=(q1/r1-q2/r2)
   NEXT j
   x(i)=i*ilength/iub+imin    'Scale x(i) to span plot area
NEXT i
FOR j=0 TO jub
   y(j)=jmin-j*jlength/jub    'Scale y(i) to span plot area
NEXT j
FOR i=0 TO nc-1 : z(i)=(i+1)/2 : NEXT i
REM
CLS: SCREEN 1,0    'CGA screen 320 by 200
LINE(imin,jmin-jlength)-(imin+ilength,jmin),,b    'Use a box for axes
GOSUB conrec
IF NOT(prmerr) THEN PRINT : PRINT : PRINT msg$;
WHILE LEN(INKEY$)=0 : WEND    'Any key to stop
CLS
END
```

Listing 4: *The QuickBASIC* VECOUT *subroutine for plotting a line segment on the screen.*

```
REM    User defined subroutine to plot vectors on whatever plotting
REM    device is available
REM
SUB vecout(xstart,ystart,xstop,ystop,clevel) STATIC
   LINE (xstart,ystart)-(xstop,ystop)
END SUB
```

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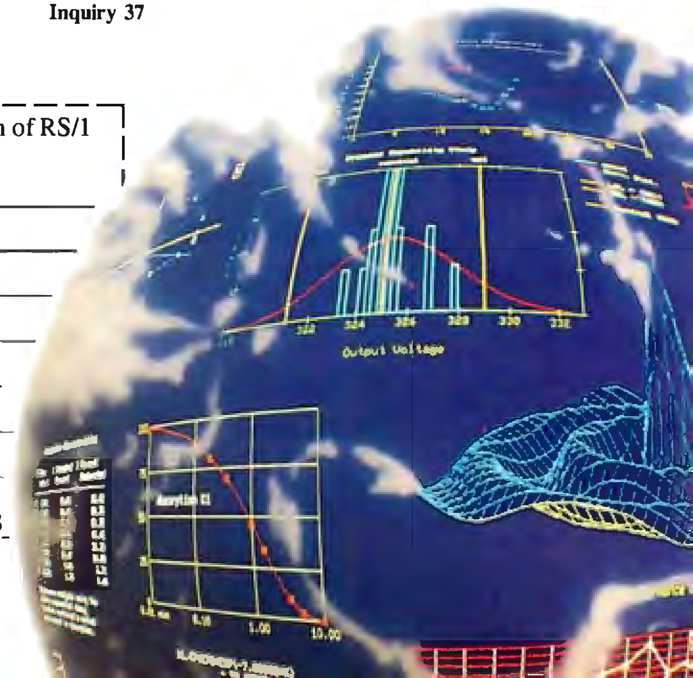

William G. Hood

Polynomial Curve Fitter

This BASIC program finds a polynomial function to fit a set of data points

People in business or industry often need to make predictions based on limited information from lab or field reports.

Situations from the scientific world come readily to mind: In testing an electroplating setup, let's say you have measured the amount of gold deposited on the surface of a metal in one hour under various voltages. You would like to find a mathematical function that describes the relationship between the independent variable (voltage) and the dependent variable (gold deposited in one hour), so you can predict how much plating will occur for any voltage.

In the area of business, suppose you have corresponding lists of monthly advertising expenditures and sales figures. You want to predict what would happen to the sales if the advertising were doubled.

In both cases, what's needed is a mathematical function $f(x) = y$ that approximates the data, with x the independent variable and y the dependent variable. The function would allow you to extrapolate (predict results outside the measurement range) or interpolate (predict additional results inside the measurement range). Plotting the function produces a smooth curve that shows the underlying trend of the data.

In this article, I'll present a BASIC program that finds a polynomial

$$p(x) = c_1x^n + c_2x^{n-1} + \ldots + c_nx + c_{n+1}$$

approximation of the empirical data, letting you try different values for n to obtain the best fit. (The variable n is known as the degree of the polynomial; c_1, c_2, . . . are the coefficients.)

When the number of data points equals $n+1$, the polynomial's graph will pass exactly through each data point. However, usually the number of data points far exceeds the degree of the polynomial, and the curve is only an approximation that does not hit each point exactly.

This type of curve-fitting is appropriate when the data points are empirical, making them subject to error. Because of the probable errors, it is not important that the graph of $p(x)$ pass exactly through each point. But it is necessary that it be a smooth curve that comes *close* to the data points. In applications where the curve must pass *exactly* through the data points, you would be better off using the methods of Bézier curves or B-splines (see "Free-Form Curves on Your Micro" by Steve Enns, December 1986 BYTE). These techniques generate a series of functions connecting the data points.

The program in listing 1 uses the *least-squares method* to calculate the coefficients c_i of the polynomial. Briefly, this method finds a "fit" (a set of coefficients) that minimizes the sum of squares of the errors. The errors are differences between the predicted values and the experimental values for the dependent variable. [Editor's note: *POLYFIT.BAS is available on disk, in print, and on BIX; see the insert card prior to page 321 for details. Listings are also available on BYTEnet; see page 4.*]

One advantage polynomial approximation has over other methods, such as the Fourier transform, is that you can evaluate polynomials easily by a program or spreadsheet or even by hand, whereas many of the other methods require far more processing.

The method of least-squares usually leads to the construction of a system of linear equations in which the coefficients of the polynomials are the unknowns. But when you use just one polynomial, the resulting system is often ill-conditioned; the solution is very sensitive to round-off error. In such cases, use double-precision arithmetic to overcome the problem. But when you fit the data points by a linear combination of *orthogonal polynomials*, you avoid the ill-conditioning and end up with a system that you can handle with single-precision arithmetic. The program in listing 1 uses the orthogonal polynomial method (see reference 1).

Using the Program

The program is written in Microsoft BASIC and will run on IBM PCs and compatibles. For other computers, you might have to make minor changes.

Whether you read in data from a disk file or type it in, each data point consists of an x and a y value and, optionally, a weight w; $w < 1$ gives a data point reduced influence; $w > 1$ gives a data point increased significance. You can give more weight to data points that you know are most accurate or to points that lie in a region of special interest. Those heavier-weighted points will have greater influence on fitting the polynomial.

After you enter the data, the program asks you to specify the degree of the polynomial you want to try; the degree must be smaller than the number of data points. With this information, the program calculates the coefficients of the polynomial approximation and prints them out in descending order of the exponent of x: coefficient of x^n, coefficient of x^{n-1}, and so forth. The program lets you try other values of n with the same data, and gives a way of gauging which degree results in the best fit.

When n equals the number of data

continued

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Listing 1: *A Microsoft BASIC program that fits a curve to a set of data points using polynomial approximation.*

```
1000 LN=1000: LD=11: REM LN=Max data points; LD=highest degree+1
1010 DEF FNMI(X,Y)=(X<Y)*(-X) + (Y<=X)*(-Y)
1020 N=0: M=0: S2=0: R2=0: MF=0
1030 S1=0: S2=0: S3=0: S4=0: P1=0: P2=0: P3=0: I=0: J=0: J1=0: K=0:
     VR=0 MM=0: WT=0: P=0
1040 DIM X(LN),Y(LN),W(LN),C(LD)
1050 DIM D1(LD),D2(LD),D3(LD),D4(LD),D5(LD),D6(LD)
1060 GOTO 1450
1070 IF MF>0 AND M>MM THEN J1=MM+1: MM=M: GOTO 1130
1080 J1=1: MM=M: S1=0: S2=0: S3=0: S4=0
1090 FOR I=1 TO N: WT=W(I)
1100 S1=S1+WT*X(I): S2=S2+WT: S3=S3+WT*Y(I): S4=S4+WT*Y(I)*Y(I)
1110 NEXT I
1120 D4(1)=S1 / S2: D5(1)=0: D6(1)=S3/S2: D1(1)=0: D2(1)=1: VR=S4-S3*D6(1)
1130 FOR J=J1 TO MM: S1=0: S2=0: S3=0: S4=0
1140 FOR I=1 TO N: P1=0: P2=1
1150 FOR K=1 TO J: P=P2: P2=(X(I)-D4(K))*P2-D5(K)*P1: P1=P: NEXT K
1160 WT=W(I): P=WT*P2*P2
1170 S1=S1+P*X(I): S2=S2+P: S3=S3+WT*P1*P1: S4=S4+WT*Y(I)*P2: NEXT I
1180 D4(J+1)=S1 / S2: D5(J+1)=S2/S3: D6(J+1)=S4/S2:
     D3(1)=-D4(J)*D2(1)-D5(J)*D1(1)
1190 IF J<4 THEN 1210
1200 FOR K=2 TO J-2: D3(K)=D2(K-1)-D4(J)*D2(K)-D5(J) *D1(K): NEXT K
1210 IF J>2 THEN D3(J-1)=D2(J-2)-D4(J)*D2(J-1)-D5(J)
1220 IF J>1 THEN D3(J)=D2(J-1)-D4(J)
1230 FOR K=1 TO J: D1(K)=D2(K): D2(K)=D3(K): D6(K)=D6(K)+D3(K)*D6(J+1): NEXT K
1240 NEXT J
1250 FOR J=1 TO M+1: C(J)=D6(M+2-J): NEXT J
1260 P2=0: FOR I=1 TO N: P=C(1)
1270 FOR J=1 TO M: P=P*X(I)+C(J+1): NEXT J
1280 P=P-Y(I): P2=P2+W(I)*P*P: NEXT I
1290 S2=0: IF N>M+1 THEN S2=P2/(N-M-1)
1300 R2=1: IF VR<>0 THEN R2=1-P2/VR: IF R2<0 THEN R2=0
1310 RETURN
1320 REM GOSUB 30 calls the subroutine
1330 REM Input:
1340 REM N=# of data points
1350 REM X( )=X-coordinates of the data points
1360 REM Y( )=Y-coordinates of the data points
1370 REM W( )=Weighting factors of the data points
1380 REM M=Degree of polynomial
1390 REM MF=0 if new data, MF=1 if old data but higher degree
1400 REM
1410 REM Output:
1420 REM C=Array of M+1 coefficients
1430 REM S2=Residual variance
1440 REM R2=coefficient of determination
1450 CLS
1460 PRINT ''Polyfit. Copyright (C) 1986 by William G. Hood''
1470 PRINT
1480 PRINT ''This program finds the coefficients of the nth degree
polynomial''
1490 PRINT: PRINT ''y = c(1)*x^n + c(2)*x^(n-1) + ... + c(n)*x + c(n+1)
1500 PRINT: PRINT ''that fits a set of data points in a least-squares sense.''
1510 PRINT ''Each data point must consist of an X value, a Y value, and an
1520 PRINT ''optional weight, separated by commas and terminated by a return.
1530 PRINT ''Data is read from a disk file until the eof is reached, or a
1540 PRINT ''specified number of data points are read in from the keyboard.''
1550 PRINT
1560 LINE INPUT ''Name the data file (null line=keyboard): ''; FI$
1570 PRINT ''Is the data weighted (Y / N, null line=No)? '';
1580 W$='' '': INPUT W$
1590 IF W$<>''Y'' AND W$<>''y'' THEN W$=''N''
1600 IF FI$<>NU$ THEN 2000
```

continued

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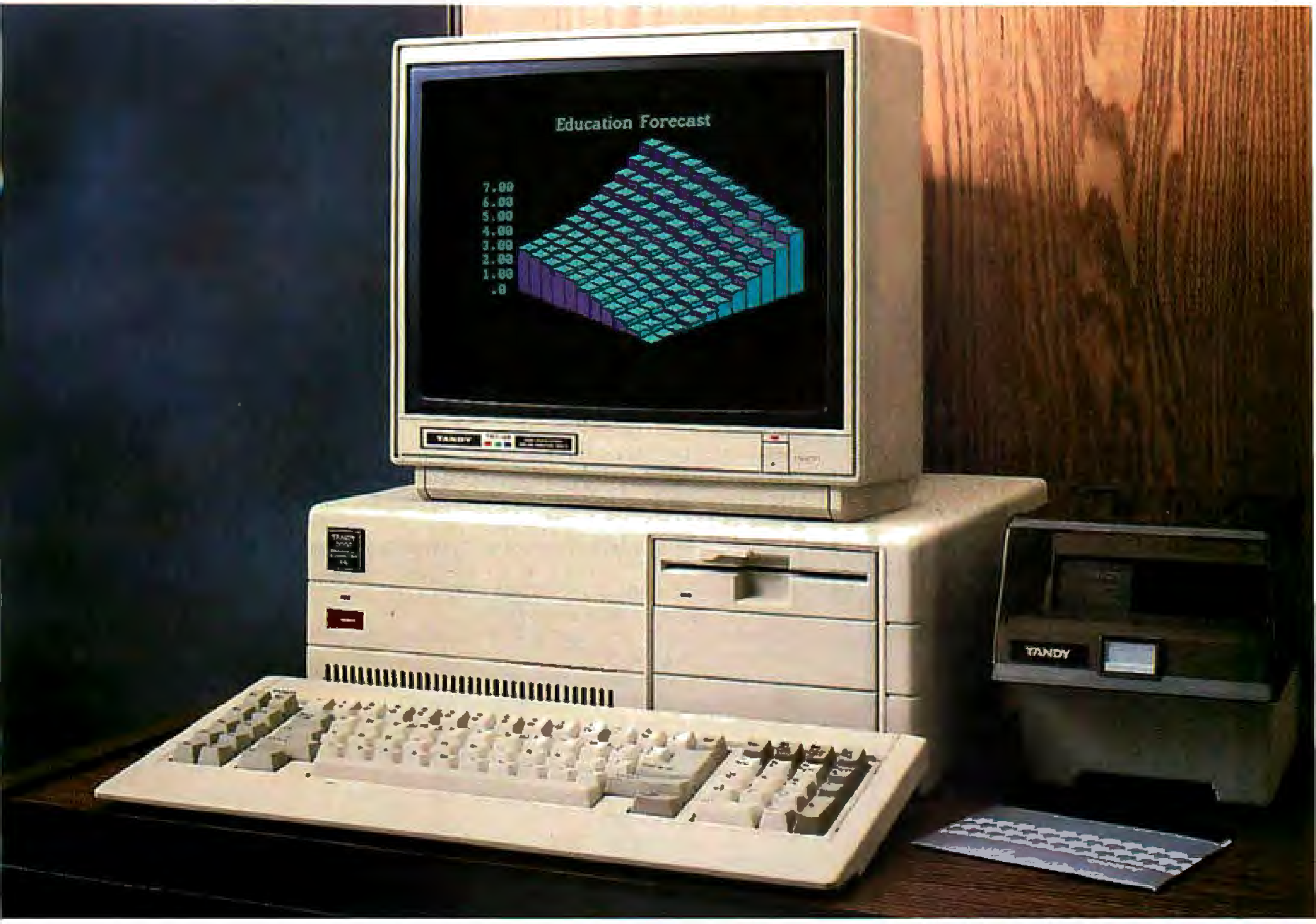

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Listing 1: *continued.*

```
1610 PRINT "Keyboard data entry"
1620 PRINT "How many data points ( 2 <= n <=";LN;")";: INPUT N
1630 IF N<2 OR N>LN THEN 1620
1640 FOR K=1 TO N
1650 IF W$<>"N" THEN INPUT "x,y,w";X(K),Y(K),W(K): W(K)=ABS(W(K))
1660 IF W$="N" THEN INPUT "x,y"; X(K),Y(K): W(K)=1
1670 NEXT K
1680 PM=FNMI(LD-1,N-1)
1690 PRINT "Degree of polynomial ( 1<= m <= "; PM;")";: INPUT M: M=INT(M)
1700 IF M<1 OR M>PM THEN 1690
1710 GOSUB 1070
1720 PRINT: PRINT "Coefficients (constant term last): ": K=0
1730 FOR J=1 TO M+1: PRINT TAB(K) C(J);: K=K+20: IF K>20 THEN K=0: PRINT
1740 NEXT J
1750 PRINT: PRINT "Residual variance: ";S2
1760 R2=INT(1000000!*R2+.5) / 1000000!
1770 PRINT: PRINT"Coefficient of determination: ";R2
1780 PRINT "Try another degree (Y / N, null line=No)";: A$="": INPUT A$
1790 IF A$="Y" OR A$="y" THEN 1680
1800 PRINT "Print a table of the data (Y / N, null line=No)";: A$="": INPUT
A$
1810 IF A$<>"Y" AND A$<>"y" THEN 1870
1820 PRINT: PRINT"Degree of p(x): ";M
1830 PRINT: PRINT " X"; TAB(11) "Y"; TAB(25) "p(x) ": PRINT
1840 FOR I=1 TO N: P=C(1)
1850 FOR K=1 TO M: P=P*X(I)+C(K+1): NEXT K
1860 PRINT X(I);TAB(10);Y(I);TAB(24);P: NEXT I
1870 IF F$<>NU$ THEN END
1880 PRINT: PRINT "Save the data (Y / N, null line=No)? ";: A$="": INPUT A$
1890 IF A$<>"Y" AND A$<>"y" THEN END
1900 PRINT: LINE INPUT "Name of output file ";FO$
1910 IF FO$=NU$ THEN END
1920 PRINT "Writing to ";FO$
1930 OPEN FO$ FOR OUTPUT AS 1
1940 FOR I=1 TO N
1950 IF W$<>"N THEN PRINT#1, X(I);",";Y(I);",";W(I)
1960 IF W$="N" THEN PRINT#1, X(I);","; Y(I)
1970 NEXT I
1980 CLOSE 1
1990 END
2000 PRINT "Reading from ";FI$
2010 OPEN FI$ FOR INPUT AS 1
2020 N=0
2030 PRINT " X" TAB(15) "Y"; TAB(28) "W"; : PRINT
2040 IF EOF(1) OR N=LN THEN 2100
2050 N=N+1
2060 IF W$<>"N" THEN INPUT#1, X(N), Y(N), W(N): W(N)=ABS(W(N))
2070 IF W$="N" THEN INPUT#1, X(N), Y(N): W(N)=1
2080 PRINT X(N) TAB(14) Y(N) TAB(28) W(N)
2090 GOTO 2040
2100 CLOSE 1
2110 PRINT: PRINT"File contained "; N;" data points."
2120 IF N<2 THEN PRINT "Too few data points.": END
2130 GOTO 1680
```

points minus 1, you are assured of a close fit. But this is not usually the case. For large values of *n*, it is not practical to find a polynomial approximation; the program arbitrarily limits the degree to 10. In practice, the largest degree is typically much smaller than the number of data points and you must try several values of degree *n* to get the best approximation.

You should try to fit a polynomial using a degree high enough that the polynomial will come close to the true function, yet low enough so that it "averages out" errors in the data. The program produces a statistic, the *residual variance*, that you can use to determine which degree gives the best fit. The residual variance is the sum of squares divided by the degrees of freedom (the number of data points minus the number of coefficients).

To find which degree gives the best fit,

continued

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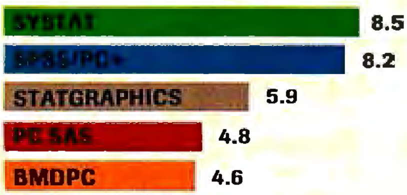

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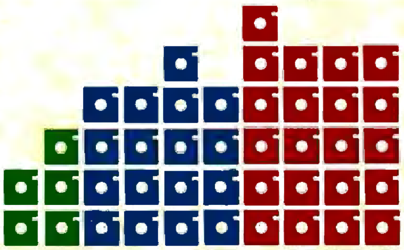

Although more comprehensive, Systat requires less than ½ the commands and has ½ the bulk of competitive programs. Compare its 5 disks to 17 for SPSS/PC+ and 21 for PC SAS!

numerous reviews and technical conference proceedings consistently prove Systat to be the most accurate statistical package available.

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."

Is cost important? Systat costs less than any other major package: less than ½ the price of the comparably equipped PC SAS or SPSS/PC+.

Truly interactive.

Unlike its major competitors, Systat has *not* ported some 20-year-old code from a mainframe program. Written specifically for microcomputers, Systat Version 3.0 uses an incredibly small amount of disk space: only 1.4 megabytes versus their 5 to 10 megabytes.

What's more, the package is genuinely interactive, freeing you from rigid command protocols. In doing so, Systat allows you to approach statistical problems more intelligently: letting you work the way you think instead of forcing you to think the way it works.

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Numerical analysis requires you to perform a large number of calculations and to interpret the results intelligently.

first fit a polynomial of degree 1 and note the residual variance. Then try degree 2, again noting the variance, which should be smaller. Continue with successively higher degrees. The degree that produces the largest decrease in residual variance over its predecessor is the best fit. For example, consider the following data:

x	*y*
0.5	3.0
1.5	7.0
2.5	12.5
5.5	14.5
6.5	16.0
9.5	14.5
10.5	16.0
12.5	16.0
14.5	21.0
15.5	23.0

When polynomials of successively higher degree are fit to this data, the program calculates the following residual variances:

Degree	Residual Variance
1	7.20688351
2	7.57981379
3	1.02062389
4	0.99174022

Although there is a decrease in going from the third- to the fourth-degree polynomial, the largest decrease is in going from the second- to the third-degree polynomial. Therefore the third-degree polynomial produces the best fit.

The smoothing effect of the third-degree polynomial is evident when you compare the plot of the third-degree polynomial with that of the ninth-degree polynomial (see figure 1). As the polynomial degree goes higher, the curve becomes increasingly spiky as it attempts to hit the points even more closely.

The program calculates another statistic, the *coefficient of determination*, which measures how much of the variation in the values of the dependent variable you can attribute to changes in the independent variable.

For instance, when you fit the above data points with a third-degree polynomial, the coefficient of determination is 0.98. This means that you can attribute 98 percent of the sum of squares of deviations of the *y* data values from their mean to changes in the *x* data values, and 2 percent to random error (assuming that the polynomial is close to the "true" function, that is, the actual physical relation between the independent and dependent variables *x* and *y*).

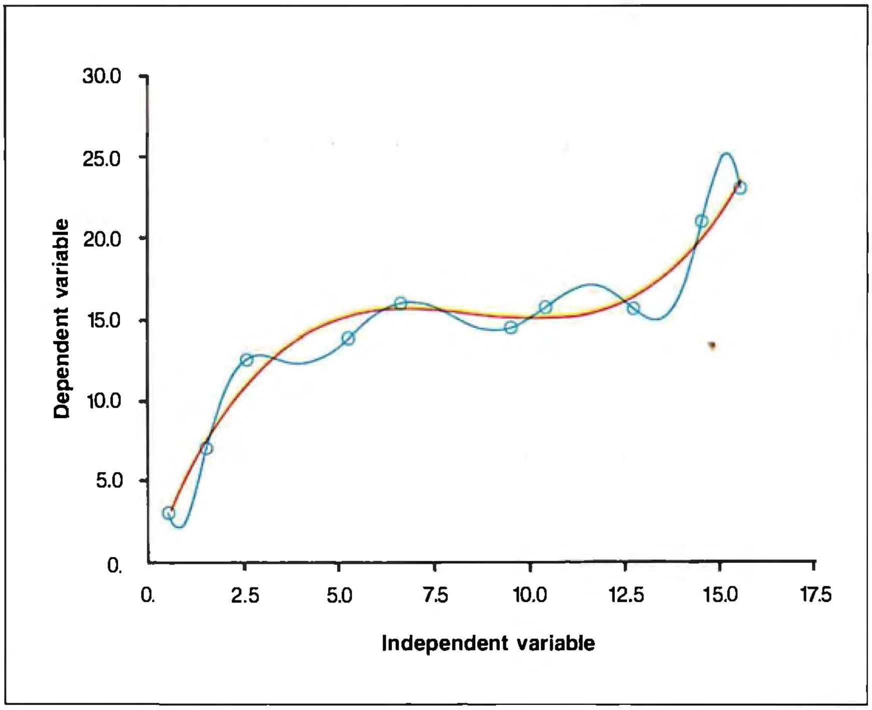

Figure 1: *Ten data points approximated by a third-degree polynomial (in red) and a ninth-degree polynomial (in blue).*

Evaluating the Polynomial

If you use the fitted polynomial in another program or spreadsheet model, you should consider the most efficient way to evaluate it; here, the obvious approach is not by any means the best.

Suppose you have the coefficients of an *n*th-degree polynomial in a BASIC array `C( )`, where `C(1)` is the coefficient for x^n, `C(2)` is for x^{n-1}, and so forth. The following BASIC code evaluates the polynomial in an obvious—but wrong—way:

```
Y=C(N+1)
FOR I=N TO 1 STEP -1
    Y=Y+C(I)*X^(N+1-I)
NEXT I
```

This code will perform $n(n+1)/2$ multiplications or execute the `EXP` or `LOG` routines *n* times, depending on the version of BASIC. To quote from an extremely useful resource book on numerical analysis, *Numerical Recipes*, "Come the (computer) revolution, all persons found guilty of such criminal behavior will be summarily executed, and their programs won't be!" (See reference 2.)

A much better approach uses Horner's rule for polynomial evaluation and requires just *n* multiplications:

```
Y=C(1)
FOR I=1 TO N
  Y=X*Y+C(I+1)
NEXT I
```

Suggestions and Caveats

You could expand the program to plot the data and the fitted polynomials. However, that would make it more machine-specific and considerably longer. A more efficient approach would be to enter the generated polynomial into a general-purpose plotting program with all the bells and whistles of scaling, labeling, dotted and dashed lines, and so forth.

Numerical analysis requires you to perform a large number of calculations and to interpret the results intelligently. This program handles the calculation, but the interpretation is still up to you. ■

REFERENCES

1. For additional information on the least-squares method and orthogonal polynomials see Ralston, A. *A First Course in Numerical Analysis*, New York: McGraw-Hill, 1965.
2. Press, et al. *Numerical Recipes: The Art of Scientific Computation*, New York: University Press, 1986.

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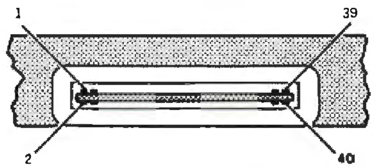
Atari 520ST Projects

An interface board for the Atari ST cartridge port

The purpose of this project is threefold: to present and test a technique for writing to the Atari 520ST's cartridge port; to build a simple but useful clock/calendar circuit; and to demonstrate some GEM dialogue-handling techniques using 68000 assembly language.

A little history is in order: One main feature of the Atari 520ST is the multitude of I/O capabilities available for the price. It has a serial port, a parallel port, a musical instrument digital interface (MIDI), a floppy disk interface, a direct-memory-access interface for hard disks, two joystick ports, and a cartridge port. With so many I/O methods, the Atari ST has a lot to offer the hardware hobbyist.

Initially, I had two projects in mind for my computer. The first would be an image digitizer that would mount on the printer's print head and let me digitize various images by using the printer to scan back and forth over the image. The second project was a floating-point coprocessor to enhance the ST's scientific and graphics applications. The most convenient connection for both projects would be the cartridge port.



ATARI 520ST CARTRIDGE PORT
(LOOKING INTO COMPUTER)

SIGNAL	PIN	PIN	SIGNAL
PWR	2	1	PWR
D15	4	3	D14
D13	6	5	D12
D11	8	7	D10
D9	10	9	D8
D7	12	11	D6
D5	14	13	D4
D3	16	15	D2
D1	18	17	D0
A15	20	19	A13
A14	22	21	A8
A9	24	23	A7
A10	26	25	A6
A12	28	27	A5
A4	30	29	
A3	32	31	
A2	34	33	
A1	36	35	
GND	38	37	
GND	40	39	

Figure 1: *The Atari cartridge port and signals.*

The Problem

While I referred to the schematic for the cartridge port, a problem surfaced: The cartridge port lacks a read/write direction-control line. It appears that the cartridge port was designed as a read-only interface. Having a useful floating-point coprocessor requires that you be able to write data as well as read results.

Although it is possible to tap into a read/write signal within the ST and bring it out to the cartridge port, some additional testing indicated that this would be a futile effort. To protect cartridges from damage due to inadvertent writes, a custom IC within the ST generates a bus error trap whenever a write to the cartridge address range is attempted for any reason. This protection feature means that you simply cannot create software that performs a write cycle to the cartridge port.

The Solution Revealed

The answer to overcoming the cartridge port's write-protection scheme is to give up using write cycles. A write cycle can be performed using a read cycle, some special software, and a little extra hardware. I admit that this sounds bizarre but, because of the 68000's addressing power, you can actually use a portion of the address lines to pass data to the cartridge port and thereby overcome the write-protection scheme.

As an example, suppose you want to write the data value $1234 to some hardware that you've attached to the cartridge port. How might you do this? A custom chip inside the ST decodes the range of addresses for the cartridge ROM address space. Two signals are produced and available cartridge-port connector. They are ROM3 and ROM4 (see figure 1 for cartridge-port pin assignments). When ROM3 is at logic zero, a read cycle is in progress from the address range of $FA0000 through $FAFFFF. Likewise, when ROM4 is at logic zero, a read cycle is in progress from the address range of $FB0000 through $FBFFFF (see figure 2 for signal timing).

The technique you use to write your data value of $1234 to the cartridge port requires placing the data on the address lines, then reading from any address in the cartridge port address map. You need some external hardware to capture the data from the address lines and pass it to your desired destination. The software to do this might look like that in listing 1. The first line defines the symbol `ROM3` to be the value `$FA0000`. Line 2 ensures that the upper half of data register `D0` will be zero when used in line 5. Line 3 loads a base address into address register `A0`.

continued

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Line 4 places the data you wish to output into data register A0. Finally, line 5 causes the data value $1234 to be placed on the lower 16 address lines while an unknown byte value is read from the cartridge port and tested for zero.

One simple hardware design for writing data using address lines is shown in figure 3. The TST.B instruction uses an addressing mode called Address Register Indirect with Index to form the address to be tested. This address is composed of three parts:

Address Register:	A0.L	= $00FA0000
Index Register:	D0.L	= $00001234
Displacement:		= $ 00 (sign extended to 32 bits)
		$00FA1234

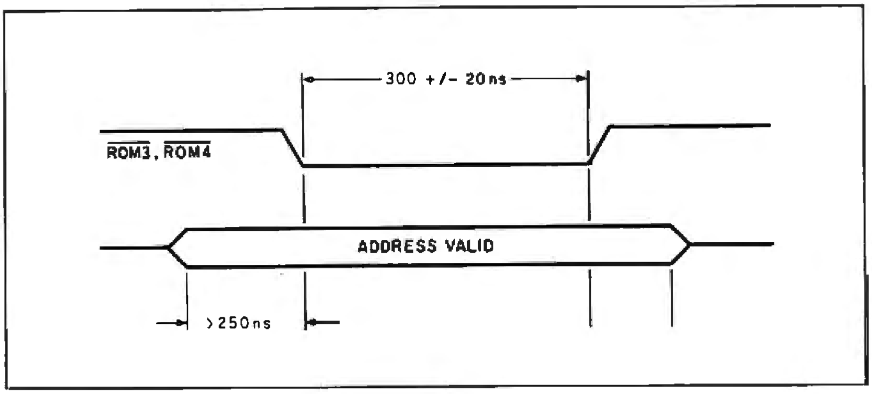


Figure 2: *Cartridge-port address timing.*

Listing 1: *Code to transfer data to the Atari cartridge port.*

```
ROM3   EQU     $FA0000     ; define ROM select address
MOVEQ  #0,D0               ; clear the register
       LEA     ROM3,A0     ; load ROM select address
       MOVE.W  #$1234,D0   ; load data into register
       TST.B   0(A0,D0.L)  ; dummy read
```

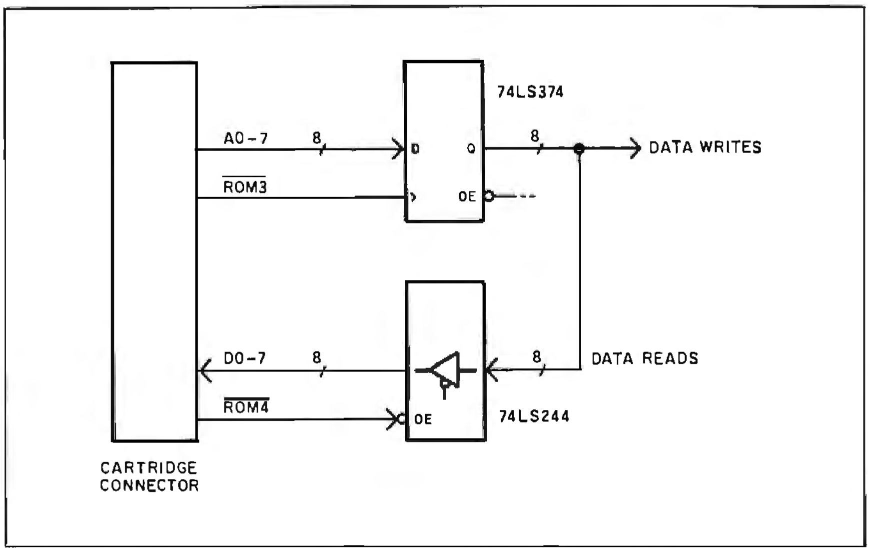


Figure 3: *A simple circuit for data separation on the cartridge port.*

Listing 2: *Code to transfer a block of data to the cartridge port.*

```
       LEA     DATA,A0      ; load address of data block
       LEA     ROM3,A1      ; load cartridge base address
       MOVEQ   #0,D0        ; ensure upper word is zero
       MOVE.W  #1023,D1     ; loop count = 1023 + 1
LOOP:  MOVE.W  (A0)+,D0     ; get next data word
       TST.B   0(A1,D0.L)   ; output word on address lines
       DBRA    D1,LOOP      ; repeat for 1024 words
```

The address $FA1234 is generated by the TST instruction and is output by the 68000, which is in turn decoded by the custom chip on the ST into a $\overline{\text{ROM3}}$ select strobe. Meanwhile the data value $1234 is presented on the lower 16 address lines during the read cycle caused by the TST instruction.

If instead of writing a single 16-bit value you wanted to output a block of 1024 data words, the program might look like that in listing 2.

With the 8-megahertz 68000 in the ST, this code executes in approximately 4.1 milliseconds, giving a data-transfer rate of a little less than 500,000 bytes per second.

Problems

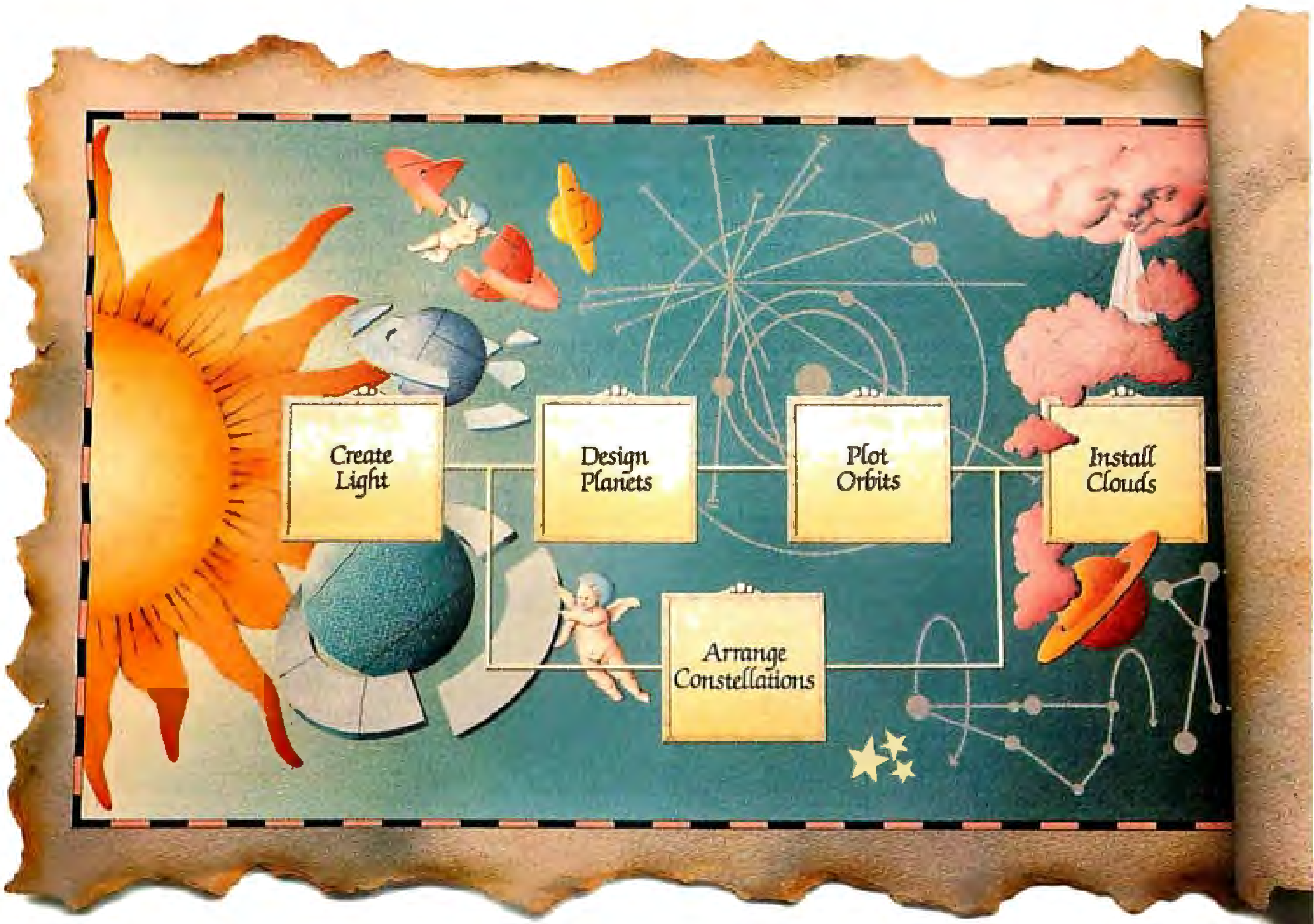
Some problems occur when you use the 16 lower address lines as data lines. Unless the data being written is guaranteed to be an even value, a byte read cycle must be performed instead of a word or longword read cycle. To do otherwise would result in a 16-bit word access to an odd address, which would cause an odd address trap and crash your program.

Also, the least significant address bit, A0, does not exist on the 68000 microprocessor. Instead, it is used to generate two other signals, the upper and lower data strobes ($\overline{\text{UDS}}$ and $\overline{\text{LDS}}$ respectively). On the cartridge-port connector, you can use $\overline{\text{UDS}}$ in place of address A0, as long as you use only byte read cycles.

When you combine the data in the index register with the address register, it is important that the upper 16 bits of the index register be zero and that the full 32 bits be specified for the index register. Otherwise, the data will be sign-extended, and the resulting address will cause $\overline{\text{ROM3}}$ or $\overline{\text{ROM4}}$ not to be selected.

You now realize that it is not as simple to write data to the cartridge port as you might have first guessed. It has the disadvantage of being slower than a direct-to-memory write cycle and requires that you perform some software contortions for every piece of data to be written. However, it does overcome the limitations of a read-only cartridge port and requires no hardware modification to the Atari ST. This method has a higher data-transfer

continued



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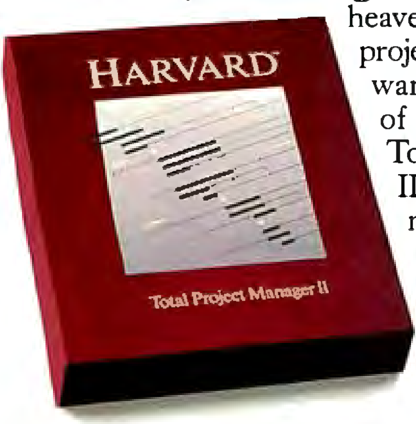

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The Test Project

I chose a clock/calendar as a test project for the cartridge-port write technique. The clock/calendar circuitry is fairly simple and the finished project is a useful addition to the 520ST. However, another problem soon surfaced when I attempted to find a prototyping board that would plug into the cartridge port. It seems that the cartridge port's 40-pin connector uses .079-inch centers between connector contacts. I tried prototyping boards with .050-, .100-, and .125-inch spacing, but none would mesh with the Atari connector. It appeared that the only solution would be to build a custom prototype board for the Atari. To my good fortune, Douglas Electronics of San Leandro, California built this custom prototyping board for the Atari and added it to their catalog of board products. The resulting general-purpose wire-wrap board is quite flexible and will support roughly fifteen 16-pin DIPs or 128K bytes of EPROM.

Having solved the problem of the Atari connector as well as which prototyping card to use, I designed the clock/calendar circuitry; the result is shown in the schematic of figure 4. The components required for this circuit are given in the parts list in table 1. The circuitry is divided into three major functional areas:

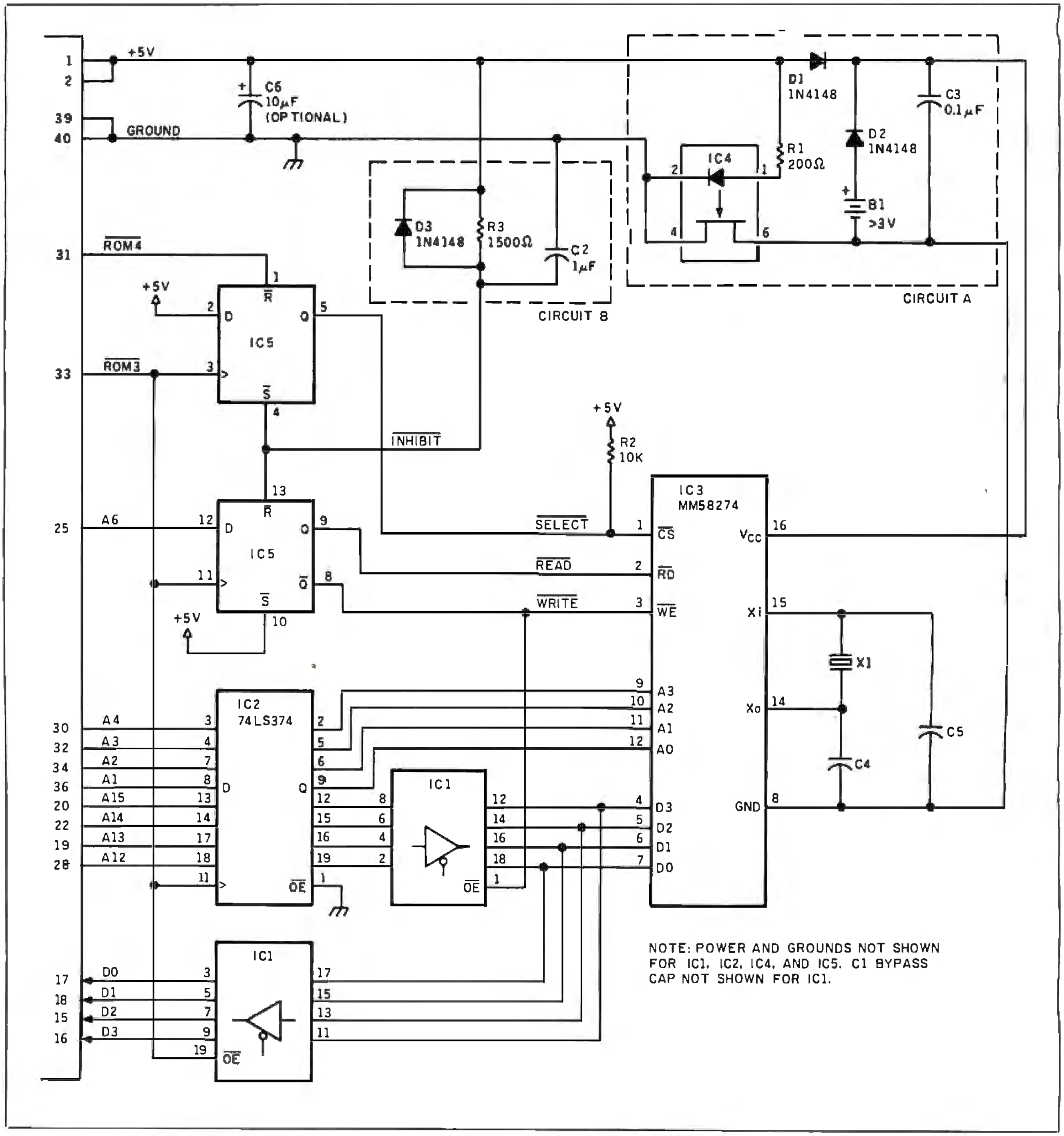

Figure 4: *The clock/calendar circuit.*

the interface to the cartridge port, the power-down isolation and keep-alive power, and the power-up/power-down glitch protection.

The Interface

Accessing the clock chip, IC3, is a three-step process. First, a 16-bit control pattern is formed and clocked into the IC2 8-bit latch and the IC5 flip-flop by using the ROM3 select strobe. This control pattern is coded as follows:

DDDD.....W.AAAA. where:

DDDD	=	data bits to write
W	=	read/write control
AAAA	=	clock register address
.	=	unused bit

The second step is a read cycle using the ROM4 select strobe. This causes the SELECT to be set low, and the clock chip is accessed for either a read or write operation setup by the W bit of step 1. If the operation is a read operation (W=0), the data from the clock chip is passed through IC1 onto the data lines of the cartridge port and is read by the software. If it is a write operation, the D bits stored in IC2 by step 1 are passed to the clock chip via IC1.

The third step involves a read cycle from ROM3 once again. This will cause the SELECT line to be set high and will end the read or write operation to the clock chip. It is possible to pipeline the accesses to the clock chip by combining step three of one access with step one of the following access.

Glitch Protection

The key to a successful battery-backup clock circuit is avoiding glitches during power-up or power-down that inadvertently produce write cycles. These write cycles can garble the time held by the clock chip. The glitch protection used for circuit B is not 100 percent reliable but is far simpler than alternative methods. The glitch-protection circuitry for power-up/power-down consists of R2, R3, C2, and D3. The R2 pull-up resistor increases the odds that the IC5 flip-flop will power up with SELECT high. The RC combination of R3 and C2 momentarily holds INHIBIT low during power up to force SELECT high and READ low. The D3 diode provides a fast discharge path for C2 so that quickly turning the power off and then on is properly handled.

Power-Down Isolation

The key to a long backup-battery life is eliminating current leakage paths during computer power-down. An effective way to do this is to disconnect the power and ground between the clock chip and battery from the rest of the circuitry.

Circuit A is used to provide power-down isolation and battery backup power while the ST is turned off. When the power is turned on, R1 and IC4 cause the ground of the clock and battery to be connected to the ground of the rest of the circuitry. With power turned off, the ground is disconnected and power is supplied through battery B1 and diode D2. Diode D1 eliminates leakage through the +5 volt line. Test measurements show a battery draw for this circuit under power-

> *Accesses to the clock chip can be pipelined by combining the read of the last access with the setup of the next access.*

down conditions of 5 microamperes. When you use a standard 110- or 150-mA per hour coin-type lithium battery, the expected battery life would be on the order of 2 ½ years.

The Software

The software consists of two programs. The first, CLOCKSET.ASM, is a program that uses GEM dialogues to verify or change the time and date of the clock cartridge. It also automatically updates the time that both TOS and GEM report. The second program, TIMESET.ASM, will automatically set the time and date during the computer boot-up sequence. [Editor's note: *Both programs are available on disk, in print, and on BIX. See the insert card prior to page 321 for details. Listings are also available on BYTEnet. See page 4.*]

The first step in writing a GEM-based program is to understand the dialogues

continued

Table 1: *Parts list for the Atari clock cartridge.*

Item	Part No.	Description	Manufacturer	Sources
IC1	74LS244	Octal buffer	—	—
IC2	74LS374	Octal latch	—	—
IC3	MM58274	Clock calendar	National Semiconductor	—
IC4	H11F1	Opto isolator	General Electric	gikey (H11F1GE)
IC5	74LS74	Dual flip-flop	—	—
X1	—	32,768-Hz crystal	—	Digikey (X32768)
B1	12325	Lithium battery	—	Digikey (P135 or P136)
BH1	—	Coin battery holder	—	Digikey (BH906ND)
D1-3	1N4148	Diode	—	—
R1	200 ohms	Resistor, 5 percent	—	—
R2	10k ohms	Resistor, 5 percent	—	—
R3	1500 ohms	Resistor, 5 percent	—	—
C1, 3	.1 μF	Bypass cap	—	—
C2	1.0 μF	Capacitor	—	—
C4, 5	18pF	Disk cap 5 percent	—	Digikey (P4403)
—	—	Header, 20 by 1	—	Digikey (929400-01-30), quantity 2
S1-5	—	20-pin WW sockets	—	Digikey (C8120), quantity 5
Board	33-DE40	Proto board	Douglas Electronics	(415) 483-8770

The Digikey references are followed by the part number in parentheses. Digikey's phone number is (800) 344-4539. Douglas Electronics' address is 718 Marina Blvd., San Leandro, CA 94577.

and windows. Dialogues are simple, fill-in-the-blank or select-a-button methods of displaying information and obtaining user input. Windows are a more general-purpose method and can be used for any number of display techniques, from screen editors to paint programs. CLOCKSET.ASM uses a dialogue because it is the simplest way to present the clock chip's time and date and to let you edit these items.

GEM provides function calls to draw a dialogue and to handle all user interaction with the dialogue in the form of the mouse buttons, and editable text fields. To use these routines, you have to define a resource tree that tells GEM how to draw your dialogue and how to react to your input. You specify a dialogue using a resource tree (a memory construct composed of a linked list of objects).

Objects are arranged in what is called a visual hierarchy. This arrangement requires that an offspring object must fit entirely within a parent object. Two or more objects within the same parent are called *siblings*. Siblings may overlap in any way or not at all. Siblings can also have their own offspring, which may have offspring, and so on, resulting in a nesting of many levels. Resource trees are arranged so that the largest object or root object is first. The objects that follow the root object are ordered starting with the root object's first offspring, followed by the offspring's offspring, and so forth to the end of the list. The resource tree's second offspring of the root object follows, followed by its offspring.

Each object has three linkages: one to the next sibling, one to its first offspring, and one to its last offspring. Each object also contains an *x* and *y* coordinate that is an offset from the upper left corner of the parent of the object. Also present is information concerning a width and a height. The width and height together with the *x* and *y* offset calculate a clipping rectangle used when the object is drawn. Objects contain a general-purpose longword that, depending on the type of the object, can be a string address, the address of a text information block or icon, or can define a border thickness and color. Also present are words with bit flags that define whether the object can be selected, has been selected, is marked, checked, crossed, disabled, and many other attributes.

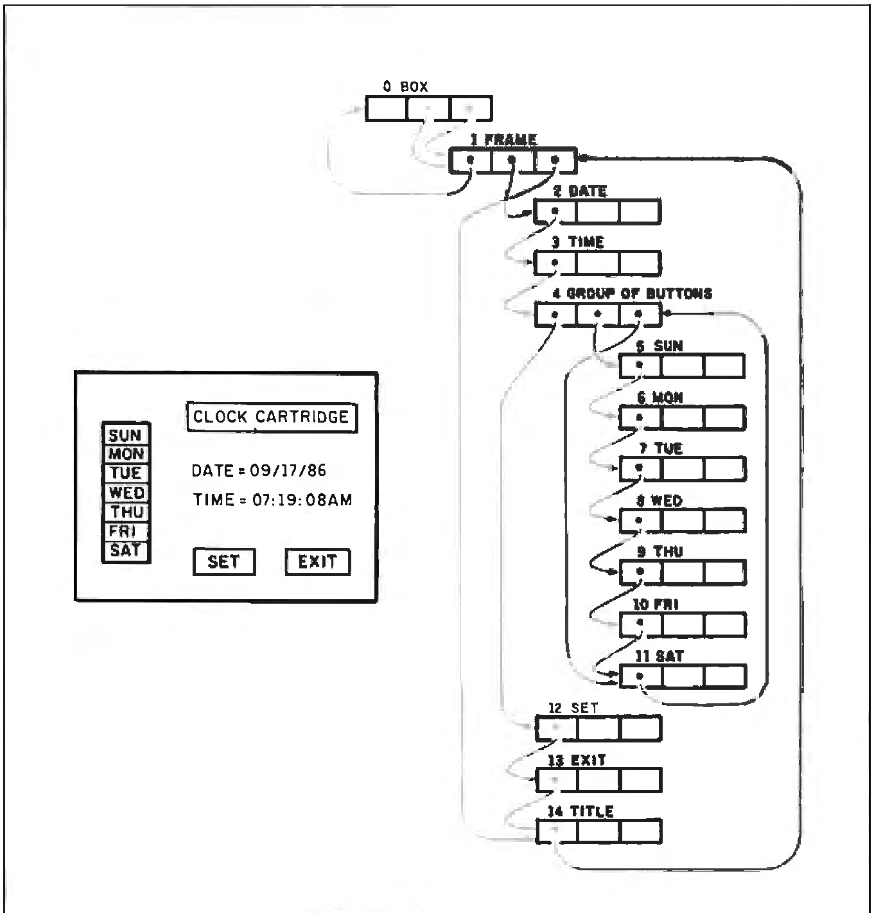

Figure 5: *The dialog box for CLOCKSET.ASM and the linkage between objects. The first object (0) is the root object, and object 1 is its offspring, or sibling. Object 1 is the parent of objects 2, 3, and 4. Object 4 is the parent of objects 5 through 11.*

The Developer's Kit available from Atari contains the Resource Construction Set (RCS) utility, which generates dialogues and other types of resources. For assembly language programming, it is convenient to use the RCS to build the dialogue and then save a C source-code version of the dialogue. This C source file is edited to convert it into a series of data statements used in the assembly language program.

Figure 5 illustrates the basic form that the dialogue box in CLOCKSET.ASM uses, as well as the corresponding linkage between the objects. Notice how the offspring objects are contained within the borders of their parent objects. Object 0 is the root object. Object 1 defines an inner framing box. Objects 2, 3, 4, 12, 13, and 14 are siblings and offspring of object 1. Objects 5 through 11 are siblings as well as offspring of object 4.

The main body of CLOCKSET.ASM is responsible for displaying the dialogue. Once the support routines are created, the procedure is fairly straightforward. CLOCKSET.ASM first initializes all GEM tables needed to make GEM function calls. The time is read from the clock cartridge and formatted for display in the dialogue. Next, a routine is called that displays the dialogue and waits for one of three buttons to be activated. CLOCKSET.ASM then processes the action required when that particular button is activated. This action will be either: exit the program (Exit), use the information on the dialogue to update the clock cartridge (Set), or update the dialogue information from the clock cartridge (Clock Cartridge). Except when you choose the Exit button, the dialogue is immediately reentered and the cycle repeats itself.

TIMESET.ASM is a short program that reads the time and date from the clock cartridge and modifies the time and date of both TOS and GEM. When it is placed in an AUTO folder, it will automatically execute during the computer boot-up process and correctly set the time, provided that the clock cartridge is present and working. TIMESET.ASM initializes the clock cartridge after power-up, reads the time and date, and updates the computer's version with this data. The time and date are also formatted and displayed on the screen. After a brief pause, the program exits. If the time or date is invalid because the battery is dead, the clock cartridge is not attached, or there is some other problem, an error message is displayed prior to exit. ■

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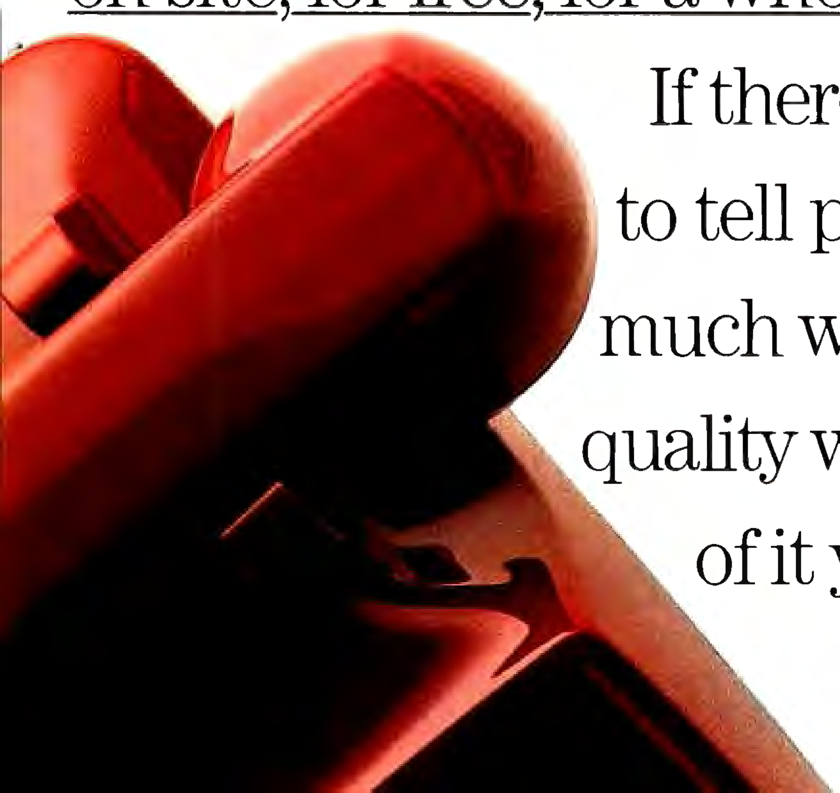

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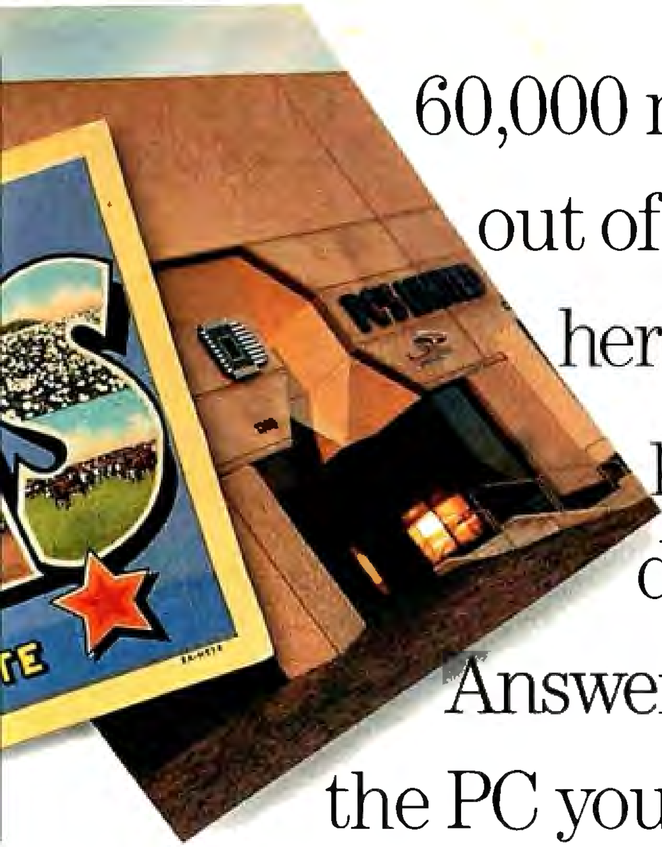

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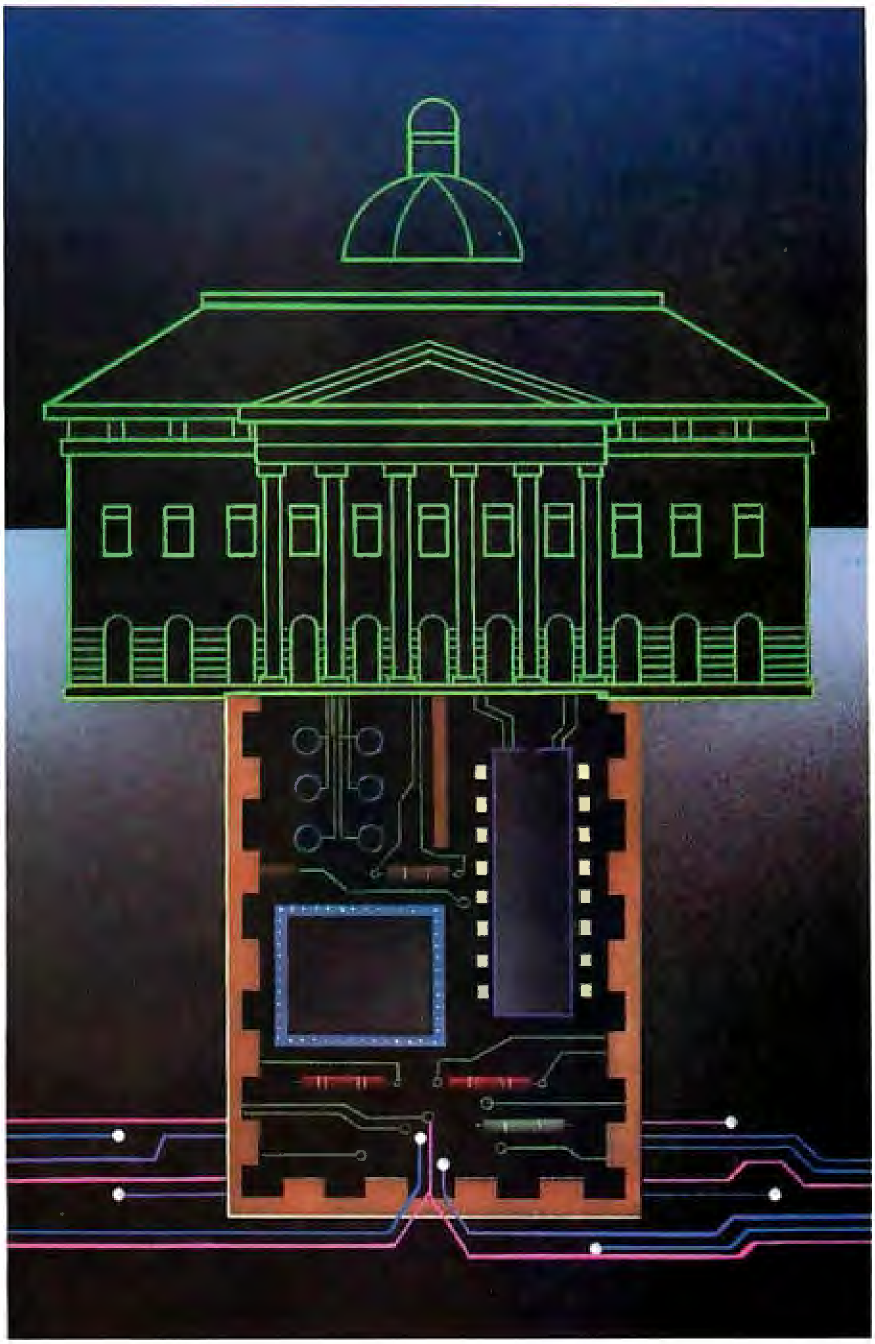

Illustration by Robert Tinney

Introduction

Computer-Aided Design

Few innovations have made an impact on manufacturing so great as that of computer-aided design (CAD). The process of designing a part that once might have taken weeks or even months to complete has been reduced to days. The return has been great, but so has the investment. In fact, not long ago that investment could have reached hundreds of thousands of dollars.

But advances in personal computer technology helped to change that. And as the price of a CAD system neared the $10,000 range, design engineers began finding more uses for CAD. One of the more interesting applications of CAD is in the field from which it emerged—electronic design. After all, CAD systems aren't limited to structural drawings.

Several companies have developed CAD systems to design and optimize electronic circuits for silicon chips. The software that outputs the circuitry artwork for semiconductors is known as a *silicon compiler*. In their article, "CAD for Building Chips," Steve Trimberger and Jim Rowson consider silicon compilers for regular arrays, partially regular arrays, and nonregular arrays.

Once a chip gets to a printed circuit board, there's another particularly helpful function that a CAD system can provide—computer-aided routing of the circuit traces. Because no two traces can cross one another, finding routes for all the traces on, say, a system motherboard can be overwhelming.

But how do you give a computer the intelligence to do the job automatically? If board real estate were not an issue, the problem would be relatively small. Writing a routine that routed traces only so they did not intersect would be simple enough, but the resulting PC board for a system motherboard might be the size of a desktop. The real trick is to use an algorithm that not only avoids intersections but also finds the shortest possible route. Stephen E. Belter, who's been involved in CAD since 1971, contributed "Computer-Aided Routing of Printed Circuit Boards," which provides a close look at one such algorithm—the so-called Lee's Algorithm.

If you'd rather roll up your sleeves and try your hand at working with a CAD program to design your own digital circuits, then read "The CADcompiler" by Arthur W. Crooke, a digital systems design consultant. Mr. Crooke knows that the drawing of a digital circuit is not nearly as important as its description, so he has written a CAD program that uses what he calls a database management approach. And Mr. Crooke has made version 1.2 of his program available to BYTE readers. You can download and begin using it to design your own circuits right away.

Of course there are other, more generic, CAD issues to consider. At the heart of any CAD software system is the data. Typically, a CAD program stores information as a collection of objects, and each of these objects is made up of graphics primitives, such as lines, arcs and circles, polygons, and splines. Other types of data the system must deal with include text and symbols. The larger and more complicated the drawing, the larger and more complicated the data will be. Structuring that data efficiently is the focus of Larry Pfortmiller's "Data Structures in CAD Software."

It's not enough to be concerned with just the internal data structures of CAD; you should also consider a way to exchange data between CAD systems. While the solution may at first seem easy—just build a direct translator between the systems—the problem grows when you consider all the varied systems available. And nearly every one handles data differently. That's where IGES (Initial Graphics Exchange Specification) comes in. IGES is a neutral file that was developed for CAD data to be what DIF (data interchange format) files are to spreadsheets. Simply put, if a CAD system can translate to and from the IGES format, then it can exchange data with all other systems that use IGES. Ralph J. Mayer, a member of the IGES steering committee, takes a critical look in his article, "IGES," at the benefits and trade-offs of the neutral file solution.

Unfortunately, we cannot cover all aspects of CAD in a single issue of BYTE. In selecting these articles for our CAD theme, we've taken a very narrow focus on CAD, but we hope it's one that you will find useful. However, to add to our CAD coverage, next month we will review several CAD software packages for the Apple Macintosh, and in the following month, several packages for the IBM PC and compatibles.

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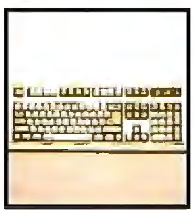

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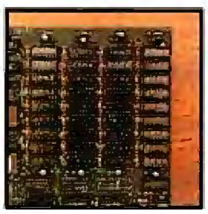

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Data Structures in CAD Software

A description of image types and their computer representation

Larry Pfortmiller

VISUALIZING OBJECTS IS an inherent part of technical design and drawing. Drawing techniques and conventions in many design and engineering disciplines have evolved into a universal form of visual shorthand that communicates both the content and the execution of an idea.

Computer-aided-design/drafting systems become increasingly accessible to designers, engineers, architects, and draftpersons as hardware and program costs decrease. CAD software is a demanding application for microcomputer-based technology due to its calculation-intensive nature. The designer of CAD programs faces an interesting spectrum of options in structuring how the software stores and manipulates the graphics elements that compose CAD images.

This article focuses on the data structures that are efficient for microcomputer CAD and discusses several ancillary issues relevant to both designer and user.

Basic CAD Approaches

There are two approaches to the design and function of CAD systems: the *design* or *three-dimensional-modeling* concept and the drafting *sketchpad* concept.

The first approach creates an analog model of the desired object or processes and stores the objects as geometric data, attributes, and relationships. This approach can be used for both visualizing a real-world object and generating traditional production drawings. The sketchpad approach creates and manages basic graphics primitives. The manual sketching and drawing of lines and arcs on paper is replaced by similar operations on a CRT screen. In what follows, I shall concentrate on this approach.

Computer-aided drafting systems store drawing information as a collection of images, items, or objects. These terms refer to the same elements; unfortunately, there is no standard terminology. The term *graphics primitives* is also commonly used to designate the base elements that compose an image.

Each image corresponds to a primitive data structure that contains most of the information necessary to fully describe each individual image. The most common drawing primitives encountered in two-dimensional CAD systems are shown in figure 1 and described below.

Points, Shapes, and Markers

A point is, conceptually, merely a location specified by a coordinate value. Unadorned points are not often needed in a finished image but can provide convenient hooks in a drawing for attaching notes and referencing locations. Many systems allow specifying codes that cause a point to be displayed with markers or shapes that can be used as dimensioning terminators (arrows, dots, slashes, boxes), flowline markers, crossover and break symbols, and the like. The geometry of such marking symbols is displayed but usually cannot be edited manually.

Lines

Lines are stored as two-coordinate values marking the line's starting and ending points. Color, line-style, width and level attributes are also usually assignable. An alternative storage representation stores a line as two pointers that point to the location of the start- and end-coordinate values. Since most drawings consist of connected line segments of the same line type, using pointers this way would seem to be more efficient.

Although the coordinate values need to be stored only once, they still need to be referenced by pointers stored in the line image. If long-integer pointers are used with double-precision coordinate values and all lines are connected in at least one place, then using pointers requires 25 percent less space for two- or three-dimensional images.

Data coordinates that are 4-byte floating-point numbers consume the same amount of space as long-integer 4-byte coordinates, but coordinate values that are 2-byte integers require 33 percent more storage for two-dimensional, and 16 percent more for three-dimensional, images. In addition, the pointer approach necessitates a reference counter stored with each coordinate to recognize when no graphics primitives use that coordinate.

Arcs and Circles

There are several methods of storing circle and arc data. The most common is

continued

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Symbols are used extensively in almost all CAD systems for representing standard elements in drawings.

storing the center points, radius, and starting and ending angles, or the starting and incremental angle with a positive or negative direction. The incremental-angle method makes it easy to identify an arc's direction. Alternatively, three points can define an arc. The start and endpoint coordinates can be stored along with a third point on the arc itself. The third point is used to compute the arc center, radius, and starting and ending angles as needed.

Polygons

Connected line segments and polygons (closed connected line segments) store a path or connected series of points or lines, all having the same attributes. The argument for pointers versus stored coordinates in the polygon is a bit different than discussed previously. For example, in two-dimensional drawings many lines are singly, not multiply, connected to other line segments. This connectivity is inherently a part of the polygon structure; thus, the use of pointers actually increases storage requirements.

In three-dimensional solids, data representing polygons using a series of coordinate pointers is preferred, since three or more polygons will almost always share the same point, reducing data storage requirements.

Curves and Splines

Curves are smooth paths that pass either through a series of points (traditionally called knot points) or near a set of points called control points. Various mathematical functions control the behavior of the curve, the most common being Bézier, beta, natural, uniform and cardinal.

The control or knot points are stored similar to the scheme used to store connected line segments or polygons. The applicable function is stored as a code that uniquely defines the method used to render the curve for the display or output device. Alternatively, the exact coefficients of the functional representation of the curve's path can be stored for each span of the curve. The span is defined as the curve between two successive control or knot points.

Text Annotation

Text characters in most CAD systems are usually represented as a series of strokes or line segments. This method allows the system to precisely scale, rotate, and skew text through procedures similar to those used to manipulate other graphics primitives. Most plotter hardware includes built-in patterns in ROM, and the CAD program's plotter drivers can choose to issue text-plotting instructions to the plotter's firmware. However, text generated in the CAD software is usually preferred. Although the software approach is slower, a wide variety of text fonts and styles can be generated.

Text primitives consist of coordinate location, scale, orientation, font type, and justification codes as well as the actual strings of characters, usually stored in ASCII. The attribute data extracts the proper character vector or stroke data from font-definition tables stored separately, either in the hard-copy output device, the plotter driver, or in the drawing itself.

Symbols

Symbols are a collection of drawings, sometimes including other symbols, that behave as a single unit. They can be saved, inserted, and transformed as a single unit instead of individual pieces. Symbols are used extensively in almost all CAD systems for representing standard elements in drawings, much as boilerplate paragraphs might be used in many different documents created with a word processor. Symbols are also called blocks, objects, components, or parts.

Each time the same symbol is used in a drawing, a reference or instance object is stored that references or points to the original copy of the symbol and its components. When symbol instances contain lists of other symbol instances, they are said to be nested. Symbols that reference

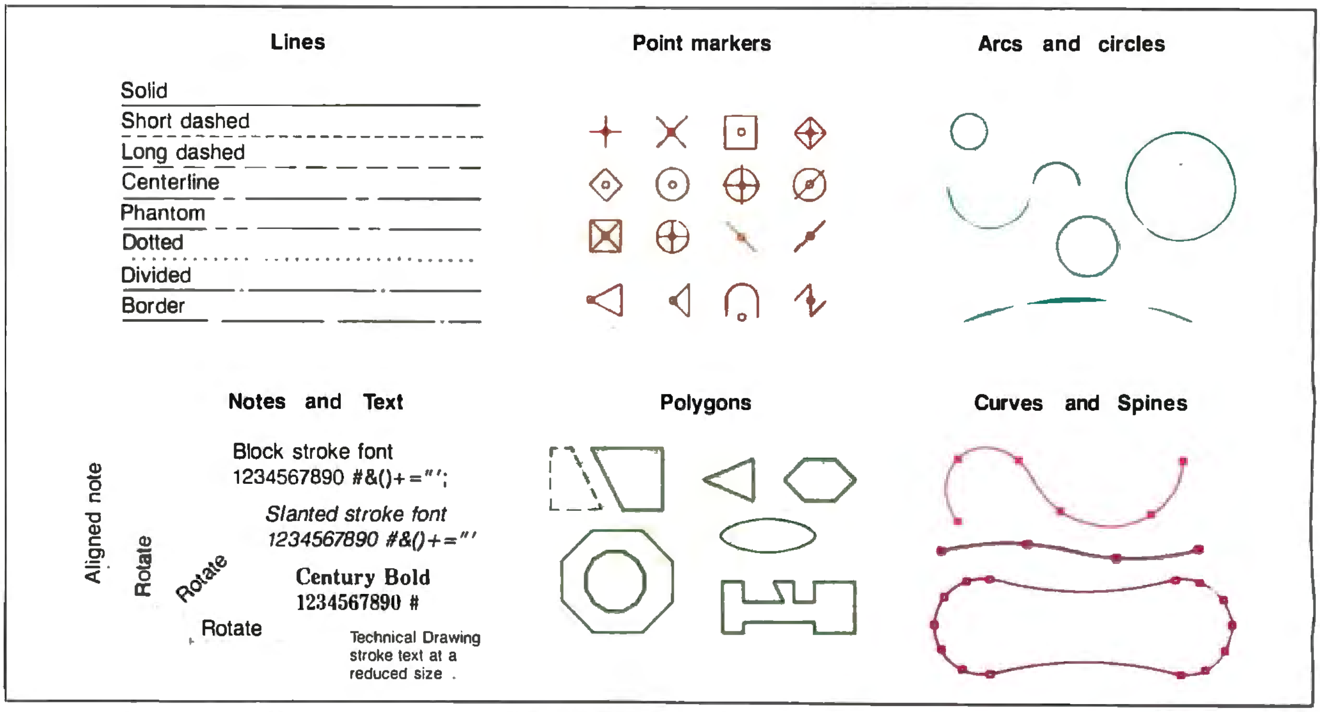

Figure 1: *The typical graphics primitives used by standard CAD programs.*

instances of themselves are not allowed.

The parts of a symbol are generally referenced to the local coordinate system of the symbol established when it was defined. An instance of a symbol is stored as an object data structure that carries the positional, scaling, mirroring, orientation, and skew geometry transform information to correctly position the symbol instance and transform its local coordinates to the global world coordinates of the drawing into which it is to be inserted.

Graphics-Primitive Attributes

Each of these graphics primitives is defined with geometric information. In addition, each primitive has data attributes to describe how it is drawn or visualized. Lines and curves will have a color, line-style, and width parameter to be used by the display and output devices to render the graphics on the device.

Since most traditional drawing pens are black on white, line styles and widths are the distinguishing graphics features. Short and long dashed lines, center lines, section and phantom lines are common and have precise meanings in a technical drawing. The various disciplines that use CAD have evolved conventions so that a given broken line pattern conveys precise information to the viewer.

These line styles and properties are related to the final drawing sheet sizes and technical-drawing conventions and do not always match nicely the metrics of an object's coordinate scales and sizes. For example, when a broken-line pattern is drawn, convention may require starting and ending on a solid line segment-¼-inch text may be standard on a D-size sheet, but on a B-size sheet it may be 3/16-inch. In most cases, the drawing annotation symbology does not relate directly to the drawing object dimensions. Instead, it is sized for final plot size and overall legibility. There are also accepted ISO and ANSI standards that specify many aspects of item size and style.

Display devices or graphics libraries rarely have the necessary built-in routines to handle these special styles.

An additional attribute or index that appears in two-dimensional drawing systems is a "layer" or "level" code. Layers are akin to the clear acetate overlays used in presentations. Symbols are used to correlate and organize information into logically connected regions in a single drawing plane; layering is used to register and correlate information that is spatially stacked in a two-dimensional drawing.

Viewing Transformations

Viewing transformations are used to transform the physical model of the data-

continued

Listing 1: *The data-structure definitions for the graphics primitives typical in a standard CAD program.*

```
typedef  struct              /* world coordinate point                    */
{
         float    x, y;
} wwcoord;

typedef  struct              /* origin, scale, angleref wcoord system     */
{
         wcoord   origin;    /* x and y origin coordinates                */
         float    xscale,    /* x scaling factor
                  yscale,    /* y scaling factor
                  angle,     /* positive x-axis rotation (radians)        */
                  skew;      /* skew factor for shear in x direction      */
} osa;
typedef  struct              /* rectangular box coordinates               */
{

         float    xmin , ymin , xmax , ymax;
} rbox;

typedef  struct              /* entity attribute data structure           */
{
         char     layer;     /* entity layer index                        */
         char     pen;       /* entity pen type code                      */
         union
         {

                  char     mark_type;    /* entity type code              */
                  char     line_type;    /* entity type code              */
                  char     font_type;    /* entity type code              */
                  char     poly_type;    /* entity type code              */
                  char     obj_type;     /* entity type code              */
         }type;
} entity_ads;

typedef  struct              /* line entity data                          */
{

         entity_ads     attrib;
         wcoord         start;      /* startpoint coordinate              */
         wcoord         end;        /* endpoint coordinate ·              */
} line_entity;

typedef  struct              /* ptmark entity data                        */
{

         entity_ads     attrib;
         osa            rcs;        /* marker positioning                 */
} ptmark_entity;

typedef  struct              /* arc and circle entity data                */
{

         entity_ads     attrib;
         wcoord         center;     /* center coordinate                  */
         float          radius;     /* radius of arc or circle            */
         float          alpha;      /* start angle of arc                 */
         float          delta;      /* incremental angle to end           */
} arc_entity;

typedef  struct              /* note entity data                          */
{

         entity_ads     attrib;
         osa            rcs;        /* note placement data                */
         int            length;     /* note string length                 */
         char           *text;      /* address of text string             */
} note_entity;

typedef  struct              /* poly entity data                          */
{
```

continued

base into a view drawn on a two-dimensional plane whose extents are either a CRT or a plotter drawing sheet. Many systems can keep track of several portions of the drawing, sometimes called views. Each view has an associated transformation matrix that transforms the global coordinates into local screen coordinates.

Design and Modeling Transforms

Modeling transformations are associated with the referencing, positioning, mirroring, scaling, rotating, stretching, skewing, and copying of drawings. As discussed earlier, items organized and stored under an object data structure (symbols) are defined in their own reference system and then transformed or mapped into the global world coordinate system of the drawing into which they are placed. Items can also be transformed between different local coordinates to move an image from ownership by one symbol to ownership by another.

The modeling transforms are similar to the viewing transforms in two-dimensional systems. If the view transformations are done in two steps—transforming from local systems to the global world coordinates, then using the display graphics interfaces to transform from the global world system to the display device coordinates—then the first-stage transforms are the same as the modeling transforms. All the images mentioned earlier can be transformed nicely except arcs and circles. When stretching, nonisotropic scaling, and skewing transforms are used, arcs and circles turn into elliptical forms. Some systems add an ellipse primitive to handle this; others treat the transformed arc or circle data structure as a special object and use the object transform data to represent the ellipse or elliptical arc.

Graphics-Primitive Data

Since graphics-primitive information is stored in a specialized form of database, CAD systems are beginning to use many standard database techniques for access, update, modification, and change. However, in most instances the CAD database must satisfy the stringent requirements of a highly interactive and responsive user interface. The principal differences are dictated by hardware constraints of interactive display and plotting systems, and the complex mathematical and geometrical relationships among the primitives themselves.

Graphics primitives by definition contain coordinate positioning information. Coordinates of the underlying object data require precise real numbers—4 bytes for floating-point numbers and 8 bytes for double-precision numbers. Four-byte

continued

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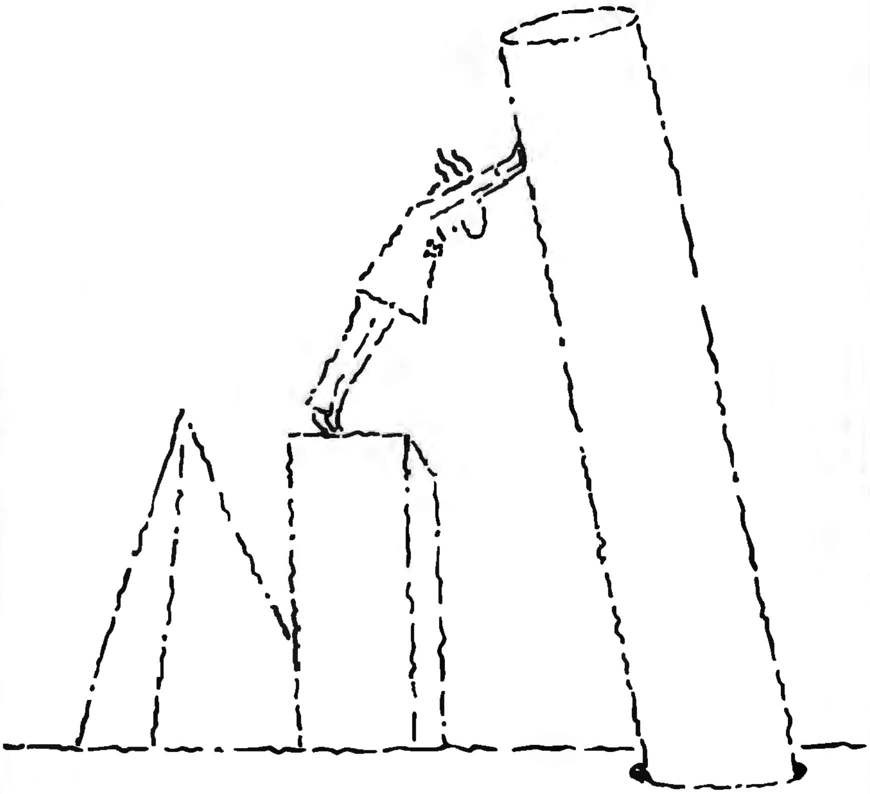

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Listing 1: *Continued.*

```
        entity_ads     attrib;
        ptmark_entity  *marker;        /* Vertex marker type          */
        unsigned       fill:1;         /* Is it filled in?            */
        unsigned       closed:1;       /* Is poly open or closed?     */
        unsigned       spline:1;       /* Is poly spline smoothed?    */
        unsigned       spline_type:4;  /* Spline function type code   */
        int            n;              /* Vertex count                */
        wcoord         *pts;           /* array of vertex coords      */
} poly_entity;

typedef  struct                   /* object data                      */
{
        entity_ads                      attrib;
        osa                             ref;   /* object placement    */
        struct      _entity_node        *entities; /* pointer to symb header */
        char                            *name;   /* address of label string  */
} obj_entity;

typedef  struct   _symb_entity          /* symbol entity data          */
{
        int                        id;          /* symbol index              */
        int                        ref_cnt;     /* symbol reference count    */
        rbox                       extent;      /* symbol extent (local)     */
        struct    _entity_node     *entities;   /* symbol entity list        */
        char                       *name;       /* address of symbol label   */
} symb_entity;

typedef  struct   _entity_node             /* entity node data struc   */
{
        struct    _entity_node     *forward;   /* next entity node pointer  */
        struct    _entity_node     *backward;  /* previous entity node ptr  */
        int                        entity_type; /* entity type & vis flags  */
        union
{
                  ptmark_dat       *point_ptr;    /* pointer to point data  */
                  line_dat         *line_ptr;     /* pointer to line data   */
                  arc_dat          *arc_ptr;      /* pointer to arc data    */
                  note_dat         *note_ptr;     /* pointer to note data   */
                  poly_dat         *poly_ptr;     /* pointer to poly data   */
                  obj_dat          *obj_ptr;      /* pointer to obj data    */
                  symb_dat         *symb_ptr;     /* pointer to symb data   */
        } ptype;
} entity_node;

typedef  struct _dbh                   /* Main drawing database header     */
{
        struct_dbh     *next;          /* pointer to next database         */
        entity_node    *vis;           /* list of visible drawing entities */
        entity_node    *masked;        /* list of blanked drawing entities */
        entity_node    *group;         /* list of workset drawing entities */
        entity_node    *symbols;       /* list of symbol header entities   */
        char           *name;          /* drawing database name            */
        char           status;         /* active - inactive status flag    */
} drawing_dbh;
```

floating-point coordinates carry 6- to 7-digit precision, and doubles carry 15- to 16- digit precision. Calculations are extensive and need to be carefully done to avoid cumulative and round-off computational errors, especially in mapping and surveying, numerical control, and other applications concerned with precision.

Integer- or whole-number-based geometry has negative connotations for most engineers and technical designers. In all but a few cases, CAD systems based on integer-coordinate data structures are considered questionable, if not unacceptable. In general, real-number accuracy and precision is desired in all applications, even though it is not always necessary for schematics, process flow, charting, and many architectural drawings.

Yet most graphics-display and plotter-output devices need integer-based coordinates. In particular, bit-map systems are integer-based. Within the range of display-screen resolutions currently used and even with large plotters, the range of 2-byte integer coordinates (−32768 to 32767) is certainly sufficient to match the resolution of these devices. In fact, additional resolution is questionable in all but specialized output devices.

CAD image coordinates must be converted to integer device coordinates before they can be displayed or plotted. For the programmer, this becomes a constant juggling act in trading off speed for accuracy and choosing between letting the application do the work or offloading it to the device-display routines. Coordinate transforms are computationally intensive and usually are done best in real numbers, as are clipping and extent checking. Simply converting image coordinates to integers and passing them to the device-display routine is usually inadequate.

Drawing Data Structure

Defining the drawing image data and putting it together in a typical CAD drawing-system database is illustrated in listing 1 and figure 2. The data structures shown are for a typical two-dimensional drafting system with 4-byte floating-point accuracy. To change to double precision, simply replace all the floats by double in the data structures in listing 1.

This drawing database is organized into three mutually exclusive, circularly linked lists of images. The visible list represents the major category of items. The workset list is a temporary working set of images that can be selected and identified for selective editing, copying, transforming, moving, and saving as standard symbol definitions. The masked list is another list for blanking or temporarily ignoring entities in the drawing database. It is used for decluttering, performance speedups, and so on.

All the display, image-selection and picking, editing, plotting, and checking routines operate from these list structures. Images are added, deleted, modified, copied, and transformed using special database-access routines. This data structure is basically the heart of the drawing system. The other algorithms and data structures connect the user interface, the file I/O, the calculator, the text-editing facilities, the unit-conversion and display formatting, the command-string parsing, the screen cursor and menu displays, the pointer input control, and the many geometry creation, calculation, and transform algorithms to form an interactive CAD system.

User-Interface Data Structures

Graphics displays used in CAD systems have evolved from vector-generated displays to bit-map displays. The latter have had a major impact on both the ability to visualize three-dimensional surfaces and

continued

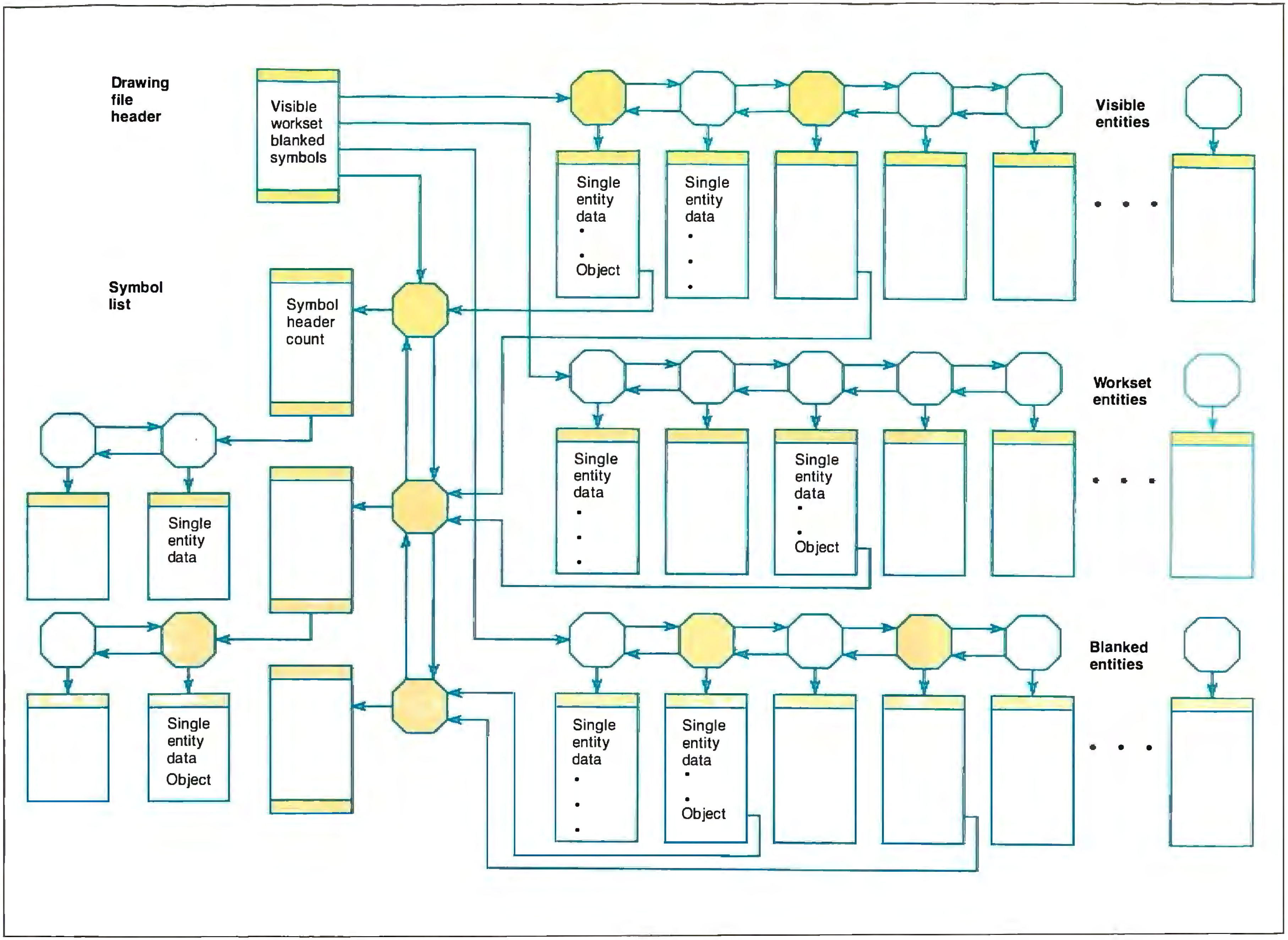

Figure 2: *The organization of drawing primitives in a CAD database.*

the way user interfaces are designed.

CAD software designed for these environments makes use of two types of graphics. Both share the display bit map. On one hand, the graphics of the visual icons, pop-up menus, and movable sprites or screen cursors is integer-based and bit-map-oriented. The image data structures and bit-blit (bit block transfer—pixel-by-pixel manipulations best performed by hardware for speed) operations that move them are the building blocks of the user interface graphics "software" control knobs. They are best done in relative screen or pixel coordinates (changing from a 640-by-200 black-and-white resolution device to an 800-by-600 16-color device including text fonts, icons, and so on requires some significant changes in bit-map data and relative screen layout that current devices and device-independent software don't handle well).

On the other hand, the displayed view of the drawing or model database images arrives at the screen pixel bit map only after completing numerous geometric and visualization transforms, again requiring many real-number computations. Serious complications arise when the user-interface graphics and the CAD applications graphics share the use of a common bit map. When windows that overlap are stacked and removed in last-open/first-closed priority and only the last (topmost) of the overlapping windows remains active, then matters are greatly simplified, assuming that bit-map memory holds out and bit-map bit-blit move operations are fast.

All these "sharing activities" can lead to nontrivial windowing-systems complexities. In future display systems, one would hope multiple applications could be fully graphically active in output and partially active in menuing control input if menus are visible, without worrying about partial redraws of a window because of an intervening application window. If much of the windowing activity is moved over to the video control side and the bit-map displays and applications can own their own bit maps as necessary, many of these problems will be solved.

Summary

The drawing primitives required for two-dimensional drafting graphics are becoming well-defined. Personal computer-based sketching and drafting systems are capable of replacing much of the traditional engineering sketching and preliminary drawing done by the designer and engineer. Current personal computer graphics-display technology is adequate for many of the tasks that required high-end workstations a few years ago. Increasing hardware horsepower and declining prices should lead to far more sophisticated CAD tools capable of providing the more complex engineering design, analysis, and three-dimensional-modeling techniques now available only on much larger systems. ■

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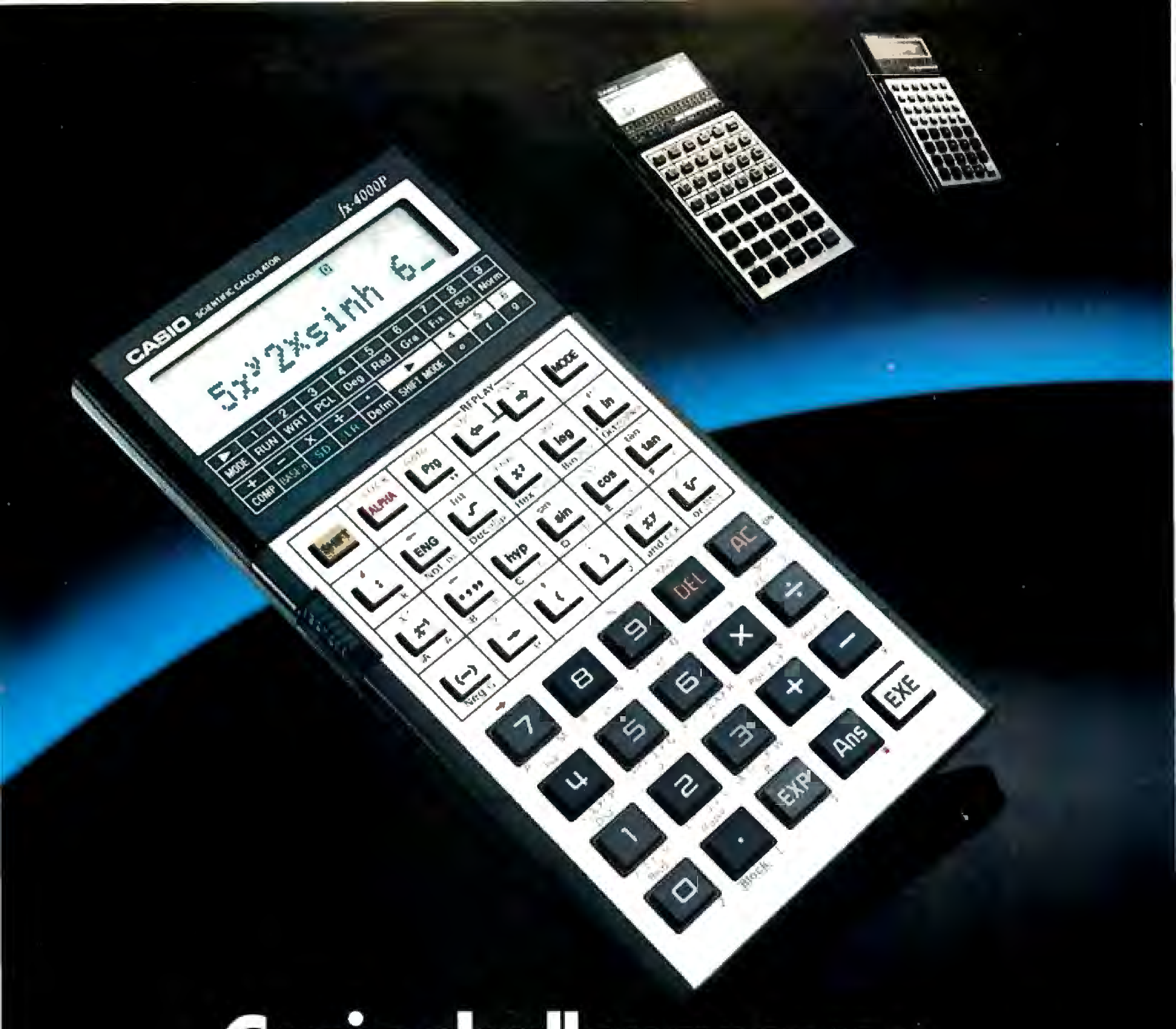
ACKNOWLEDGMENTS

Special thanks to David Hull, Dave Staudacher, Lorenz Huelsbergen, Louie Pfortmiller, and Paul Van Vleck for their support and comments in preparing the paper, and to Glen Hart for his assistance in organizing and editing the manuscript.



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The CADcompiler

A logic design tool with a twist

Arthur W. Crooke

THE CADCOMPILER IS A logic design tool with a different twist on the usual method of creating digital circuits. Instead of using a schematic drawing approach, the CADcompiler uses a database management system to enter and manipulate parts lists and connectivity information to automate the design of circuits. With this information, the CADcompiler then uses character-mode graphics, instead of pixel graphics, to generate a schematic for presenting the design in an easily readable format.

Version 1.2 of the CADcompiler is available in binary format for the IBM PC, along with a documentation file and a sample design. [Editor's note: *Version 1.2 object code for the IBM PC and compatibles only and accessory files are available on disk, in print, and on BIX; see the insert card prior to page 321. The object code is also available on BYTEnet; see page 4.*]

Inception

The CADcompiler was developed by a group of digital-system design engineers for use on a personal computer. It includes features essential to the complete development of digital board-level products. It has been tested and modified over several years to improve speed and functionality, simplify operation, and improve error checking. At the outset of its development, a number of system requirements were specified:

- It should improve the designer's efficiency by automating as many time-consuming elements of the product development cycle as economically possible.
- It should make the designer self-sufficient by minimizing the need for support services.
- Where external services are required, it should provide clean, accurate, machine-readable interfaces (e.g., for printed circuit layout, wire-wrap, simulation, and so on).
- It should simplify generating a clear description of the product, both before the start of the design and on completion of the project.
- It should run on a low-cost system (an IBM PC or compatible with a dot-matrix printer, monochrome display, 256K bytes of memory, and no other options).

The Drafting Approach to Logic Design

These five objectives were considered with respect to the following tasks traditionally necessary to bring a digital product from concept to production:

a. Develop the concept: Make a sketch or block diagram to illustrate the product.
b. Make a mechanical drawing of the details for construction (a picture of the components and interconnecting wires).
c. Make timing and state diagrams, and flow charts to check the design.
d. Build the product from the drawings.
e. Check out the product using the drawings and specifications.
f. Make changes to correct for deficiencies found in the application of the product, or to expand the design.
g. Provide user and maintenance documentation.

Modern CAD systems rely heavily on automated drafting (since they tend to emulate the manual processes fairly closely) and therefore require more capable computers than other personal computer applications such as word processing or spreadsheets.

This emulation approach to logic design is considerably more difficult than just drafting (task b), since the parts list and connectivity information must be extracted for use in construction (task d) if that too is to be automated. This same information is also needed for simulation (task c) and automated testing (task e).

Engineering change control (task f), one of the most important features of design automation, is often overlooked or compromised, especially in low-cost systems. Though the description of the product for both concept development (task a) and maintenance (task g) is often not considered part of the automation process, systems with good hierarchical design features can support these tasks as well.

A Database Management Approach to CAD

Digital products differ from most others (mechanical or architectural) in one important respect regarding CAD: The drawing is not an essential part of the design's description and, in fact, does not

continued

Arthur W. Crooke (34 Drum Hill Rd., Concord, MA 01742) is an independent design consultant who specializes in digital systems, instrumentation, and signal processing hardware design.

form a complete description for automatic-manufacturing purposes. The actual design is completely specified by a parts (device) list and a netlist (a list of networks of connected device pins).

Component placement and board assembly are mechanical functions of the specific implementation (wire-wrap or printed circuit board) and do not directly affect the design. In fact, breadboards are often built in one technology and production units in another. The design should not change in the transition.

The essential functions of a digital CAD system, therefore, are entry (design capture), checking and maintenance of the netlist and parts list, and preparation of appropriately formatted output for manufacturing. The conventional approach of "drawing a picture of all the wires" is time-consuming, produces documents that are hard to read, and leads to errors that are hard to detect. Large graphics-based systems generally provide an alternative based on a structured hierarchy of block diagrams that, at

continued

ADDR00	U01-19, U03-2
ADDR01	U01-18, U04-8, U05-10, U06-8, U07-10, U10-10, U11-10
ADDR02	U01-17, U04-7, U05-9, U06-7, U07-9, U10-9, U11-9
ADDR03	U01-16, U04-6, U05-8, U06-7, U07-8, U10-8, U11-8
ADDR04	U01-15, U04-5, U05-7, U06-5, U07-7, U10-7, U11-7
ADDR05	U01-14, U04-4, U05-6, U06-4, U07-6, U10-6, U11-6
ADDR06	U01-13, U04-3, U05-5, U06-3, U07-5, U10-5, U11-5
ADDR07	U01-12, U04-2, U05-4, U06-2, U07-4, U10-4, U11-4
ADDR08	U02-19, U04-1, U05-3, U06-1, U07-3, U10-3, U11-3
ADDR09	U02-18, U04-23, U05-25, U06-23, U07-25, U10-25, U11-25
ADDR10	U02-17, U04-22, U05-24, U06-22, U07-24, U10-24, U11-24
ADDR11	U02-16, U04-19, U05-21, U06-19, U07-21, U10-21, U11-21
ADDR12	U02-15, U03-8, U05-23, U07-23, U10-23, U11-23
ADDR13	U02-14, U05-2, U07-2, U10-2, U11-2
ALE	U01-11, U02-11, U08-61
BHE*	U02-8, U08-64
DATA00	U01-1, U04-9, U05-11, U08-17
DATA01	U01-2, U04-10, U05-12, U08-15
DATA02	U01-3, U04-11, U05-13, U08-13
DATA03	U01-4, U04-13, U05-15, U08-7
DATA04	U01-5, U04-14, U05-16, U08-8
DATA05	U01-6, U03-8, U05-23, U07-23, U10-23, U11-23
DATA06	U01-14, U04-16, U05-18, U08-4
DATA07	U01-8, U04-17, U05-19, U08-2
DATA08	U02-1, U06-9, U07-11, U08-16
DATA09	U02-2, U06-10, U07-12, U08-14
DATA10	U02-3, U06-11, U07-13, U08-15
DATA11	U02-4, U06-13, U07-15, U08-10
DATA12	U02-5, U06-14, U07-16, U08-7
DATA13	U02-6, U06-15, U07-17, U08-5
DATA14	U02-7, U04-16, U05-18, U08-3
DATA15	U01-17, U07-19, U08-1
DEN*	U03-6, U08-39
DXHBS*	U03-13, U11-20
DXLBS*	U03-12, U10-20
EPMHBS*	U03-16, U07-20
EPMHBS*	U03-18, U05-20
GND	U01-9, U02-9, U08-46, U08-47, U08-50
LCS*	U03-3, U08-33
PLC	U08-49, U08-55
RD*	U04-20, U05-22, U06-20, U07-22, U08-62, U10-22, U11-22
REC*	U03-7, U08-40
RMHBS*	U03-17, U06-18
RMLBS*	U03-19, U04-18
UCS*	U03-4, U08-34
VCC	U05-1, U05-27, U07-1, U07-27, U10-1, U10-27, U11-1, U11-27
WR*	U04-21, U06-21, U08-63
XTAL01	U08-59, U09-1
XTAL02	U08-58, U09-2
ZGND	U01-10, U02-10, U03-10, U04-12, U05-14, U06-12, U07-14, U08-26, U08-60, U10-14, U11-14
ZVCC	U01-20, U02-20, U03-20, U04-24, U05-28, U06-24, U07-28, U08-9, U08-43, U10-28, U11-28

Figure 1: *A CADcompiler netlist containing signal names shows the device pins that are to be wired together for a given design.*

AD16	U08-68
AD17	U08-67
AD18	U08-66
AD19	U08-65
ADDR14	U02-13
CLKOUT*	U08-56
DATA16	U10-11
DATA17	U10-12
DATA18	U10-13
DATA19	U10-15
DATA20	U10-16
DATA21	U10-17
DATA22	U10-18
DATA23	U10-19
DATA24	U11-11
DATA25	U11-12
DATA26	U11-13
DATA27	U11-15
DATA28	U11-16
DATA29	U11-17
DATA30	U11-18
DATA31	U11-19
DELBHE*	U03-5
DEN	U03-15
INTA00*	U08-42
INTA01*	U08-41
INTI00	U08-45
INTI01	U08-44
MBHE*	U02-12
REC	U03-14
RES*	U08-24
RESET	U08-57
TMRI00	U08-20
TMRI01	U08-21
TMRO00	U08-22
TMRO00	U08-23

Figure 2: *A list of single pins and the other pins to which they are connected.*

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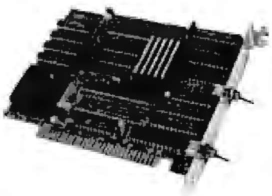

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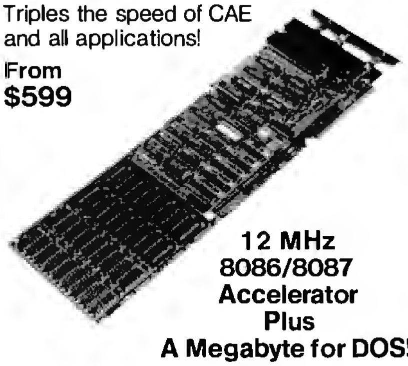

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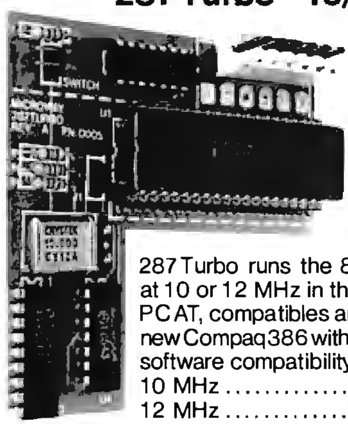

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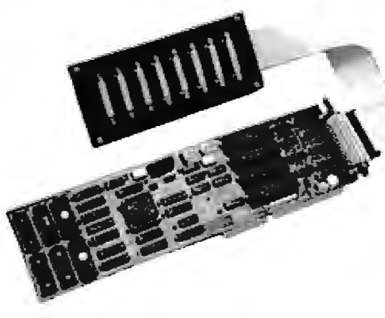

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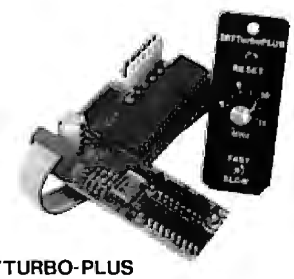

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the lowest level, reduce to logic diagrams or even component schematics.

As an alternative, I have implemented a specialized logic-design DBMS. Data is input via "entry forms" (that look like logic diagrams) with a convenient editor that has special functions for entry of register-level (data bus) functions and copying devices. The database format is tailored for efficient storage of design and component library data, as well as for fast access. Many "report" formats are provided—several that look like schematics, plus a number of netlist formats required by different construction services, as well as several for use by the designer for design checking.

Signal Names

The database maintains a list of pin-designator (DEV-PIN)/net-designator (SIGNAL) pairs (the netlist) and a list of device-designator/device-type pairs (parts list). A net is a set of device pins to be wired together to form a network. For the database system to work, these nets must be assigned a name (*net name* or *signal name*) by the designer. Although this seems a tedious use of the imagination compared to drawing a line between two points on a diagram, there are many advantages to using signal names.

With the availability of high-speed field-programmable logic devices, using

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(L)ibrary Maker (D)esign Maker (N)etlist (C)hange List

(P)arts List (A)rrange Design (S)chematic

(E)xtract and Merge <esc> Return to Operating System

Command?
```

Figure 3: *The CADcompiler main menu.*

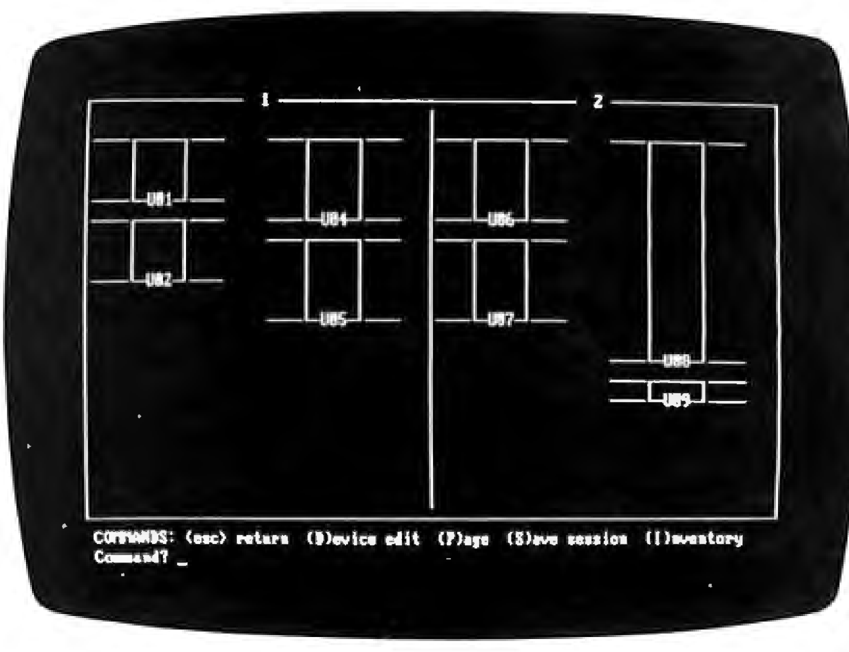


Figure 4: *A CADcompiler completed entry form, showing the currently assigned signal names on the corresponding pins.*

An important aspect of a personal computer CAD system is the ease with which the integrity of the design can be maintained.

small-scale integrated devices is no longer cost-effective. Modern designs tend to combine register-level MSI components, memories, and VLSI components interconnected with programmable array logic devices. The program for the PALs can most easily be described by Boolean equations converted to the format required by the device programmer using one of several assemblers, such as PALASM from Monolithic Memories or CUPL from P-CAD Systems. These equations are most useful when the inputs and outputs are given meaningful names, in which case interconnecting lines are generally unnecessary and may only add confusion.

A signal name can be useful in both design and checkout of the product if chosen to be suitably mnemonic of the function of the signal that appears on the designated net. Signal tracing is simplified when an alphabetically sorted, well-formatted signal list (netlist) is available, especially when related groups of signals are given names that are close in alphabetic order.

Use of a fixed number of digits for data bus bit numbers is important to maintain the sequence when sorted alphabetically. Figure 1 illustrates such a signal list. It is relatively easy to identify signals that may be overloaded by looking for those connected to a large number of pins. The single-pin list, illustrated in figure 2, flags potential errors, since a pin to which a name is assigned is usually meant to be connected to another pin.

Even with drafting-oriented systems, a name is required for every net, and one will be assigned automatically (not mnemonically) by the system if not done by the designer. Transferring data from one system to another can produce connectivity errors if the receiving system allows fewer characters in the signal name than were created by the algorithm of the sending system. In such cases, it is often necessary to assign a name to every net, reducing the advantage of drawing pictures of the wires. It is also often necessary to check the netlist at various points, an especially difficult process if the names are not meaningful and the list is not well-formatted.

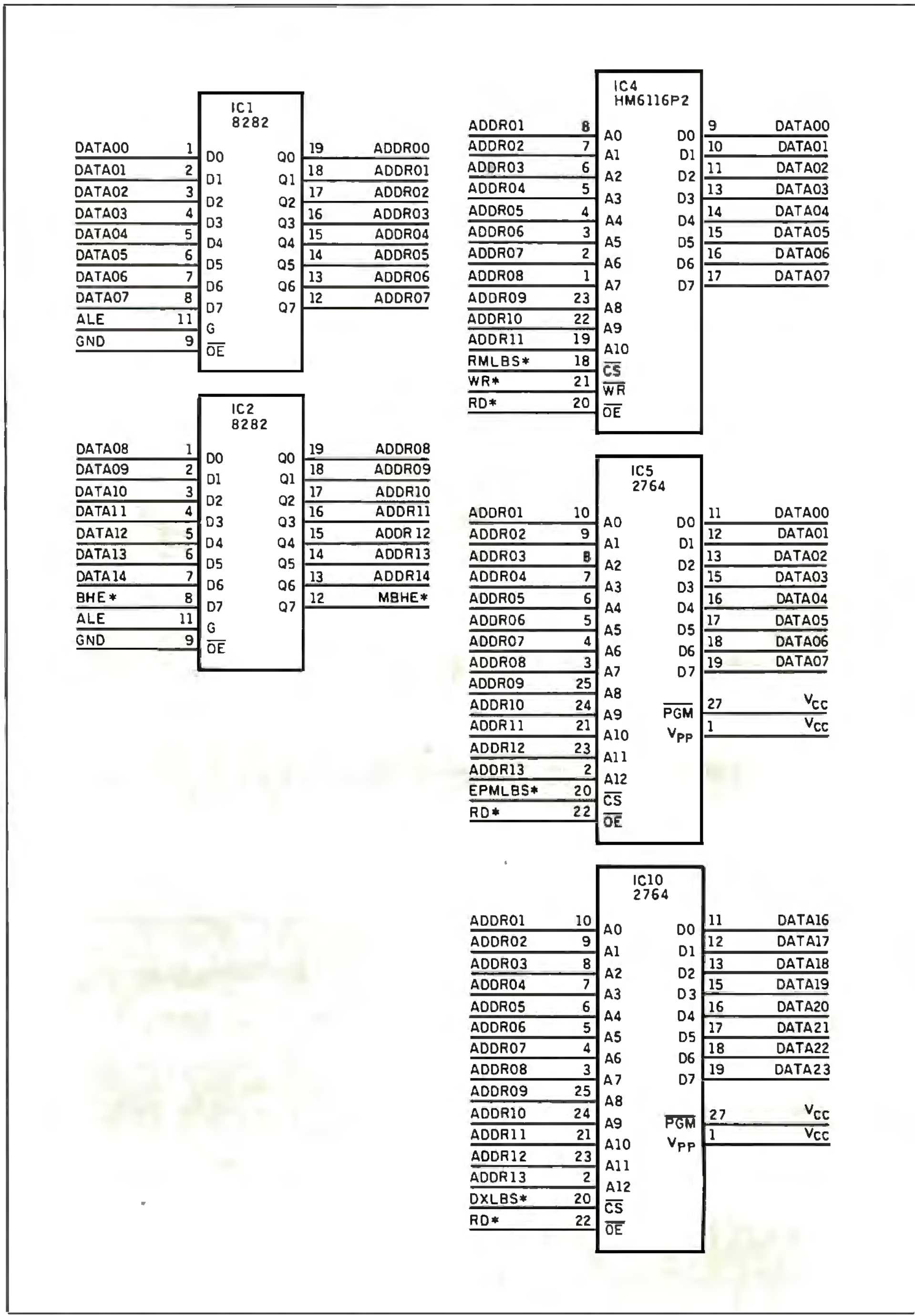
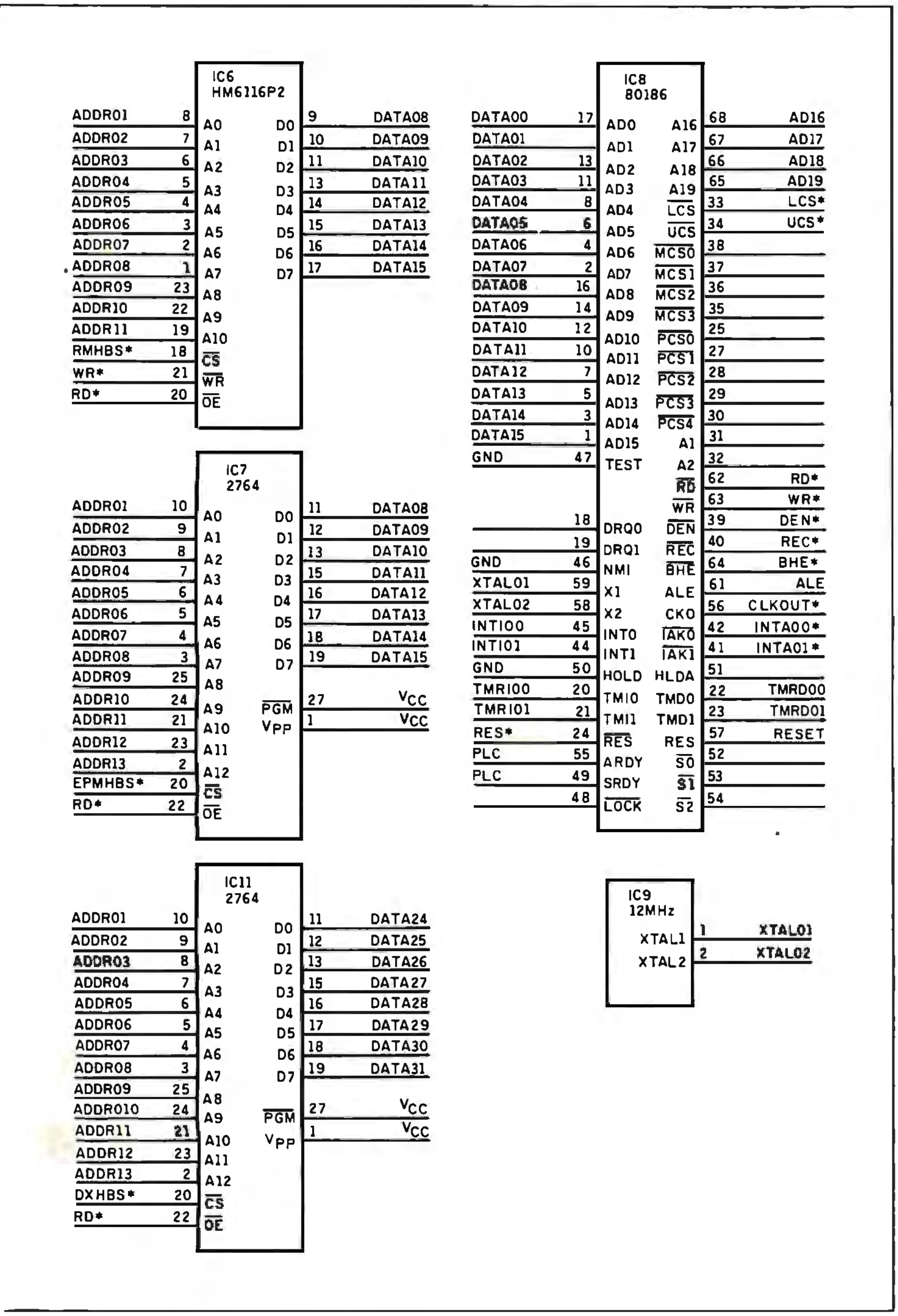


Figure 5: *A CADcompiler schematic with each device shown separately, along with the signal names listed next to their corresponding pins.*

Database Structure

An important aspect of a personal computer CAD system is the ease with which the integrity of the design can be maintained. The data for a design should not expand to the point where a full-time system manager is required to perform regular backup and other routine functions. The complete description of a reasonable-size design should fit on a single 360K-byte floppy disk, including such peripheral items as component data and technical manuals. The design program and other supporting information should also be contained on a single disk and be able to operate on reasonable-size designs in a minimum system.

Storage economy results from the use of an efficient relational database manager program that permits separation of design and component data into individ-



ual files, of similar structure, consisting of fixed-length (128-byte) records. Four records are reserved for file maintenance to permit reuse of space relinquished by deleted components in order to eliminate the need for periodic "packing" (rewriting) of the file. The average file size is 500 bytes per integrated circuit.

Program Structure

The CADcompiler system, written in Microsoft Pascal, was developed as a set of separate programs using common utility routines and library files. They were then compiled as a set of modules directed by a menu-driven command interpreter. Memory requirements were minimized by placing each module in a separate overlay, with the interpreter and utilities in the main program. The overhead for swapping modules is negligible, since the minimum time each function is used is normally measured in minutes.

continued

Another advantage of this structure is that the program remembers the current design context as the designer moves from one module to another, and is able to provide reasonable default file names as needed to minimize typing.

The modules available in the current version of the program are listed in the top-level menu (see figure 3.) Each module is accessed by typing the letter in parenthesis before the name, and generally responds with requests for necessary file names. Once the basic design name is entered, the default values are usually reasonable and can be accepted with a carriage return or modified. At any point the user can return back up the menu tree by pressing the Escape key.

Design Data Entry

Entry of new data or design modification can be accomplished easily from either a block diagram or marked-up schematic. Selection of the design module initiates a request for a design file name and a library file name, then proceeds to a menu with options to change/add/delete a device or provide an inventory of the design's contents. A device is selected by entering a name of up to 10 characters (normally a sequential designator such as U01). For best formatting, the same number of digits should be used in all designators. If the device has not already been entered, a request is made for a device type that must match a device in the selected library.

When the preliminary data is complete, the entry form is displayed as a logic symbol for the selected device, with the currently assigned signal names on the corresponding leads (see figure 4). A 10-character-wide reverse video field can be moved from pin to pin for entry or modification of signal names. Convenient cut-and-paste options and auto-incrementing or decrementing of bit numbers for data buses minimize the amount of typing required.

When data for a device is complete, the Escape key invokes a request to save the data or exit to the menu without saving. Further typing is often saved by copying the data from one device to a new designator so that only the differences need be entered.

Library Data Entry

The library entry form is essentially the same as that for design entry. If the device already exists, then the form looks the same as for the corresponding device in a design, except that the cursor can move to the 3-character pin number field and the 5-character pin function field. The 7-character field corresponding to the signal name field of the design form is for entry of pin-related parameters.

For example, a Z in this field tells the netlist report generator to take the pin function field (usually GND or VCC), prefix it with a Z, and add it to the netlist for the corresponding pin of any device using this part in the design. It also tells the design entry module not to display this pin on the entry form, and the drawing report generator not to show the pin on the drawings. This feature eliminates the need for entry of these signals and also puts them at the end of the netlist for convenience in checking.

If the part is not in the library, a small box is displayed with space for one lead on each side. The box can be lengthened for provision of up to 100 leads on a side. No leads are shown until the pin number has been entered. After entry of pin numbers, functions, and parameters, pressing the Escape key invokes requests to save and for device-related information such as physical width and width on the drawing reports. Completion of this data causes a return to the library menu.

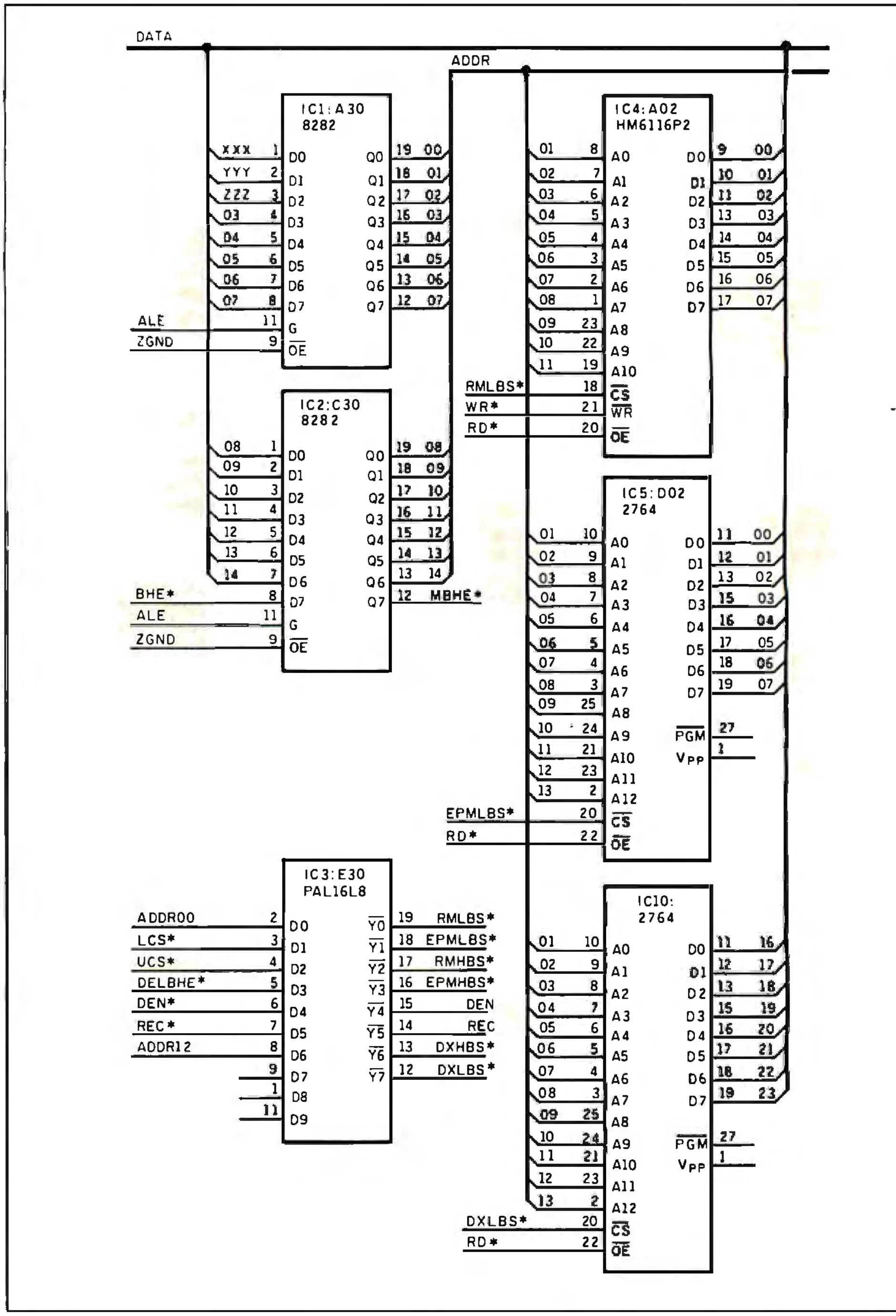
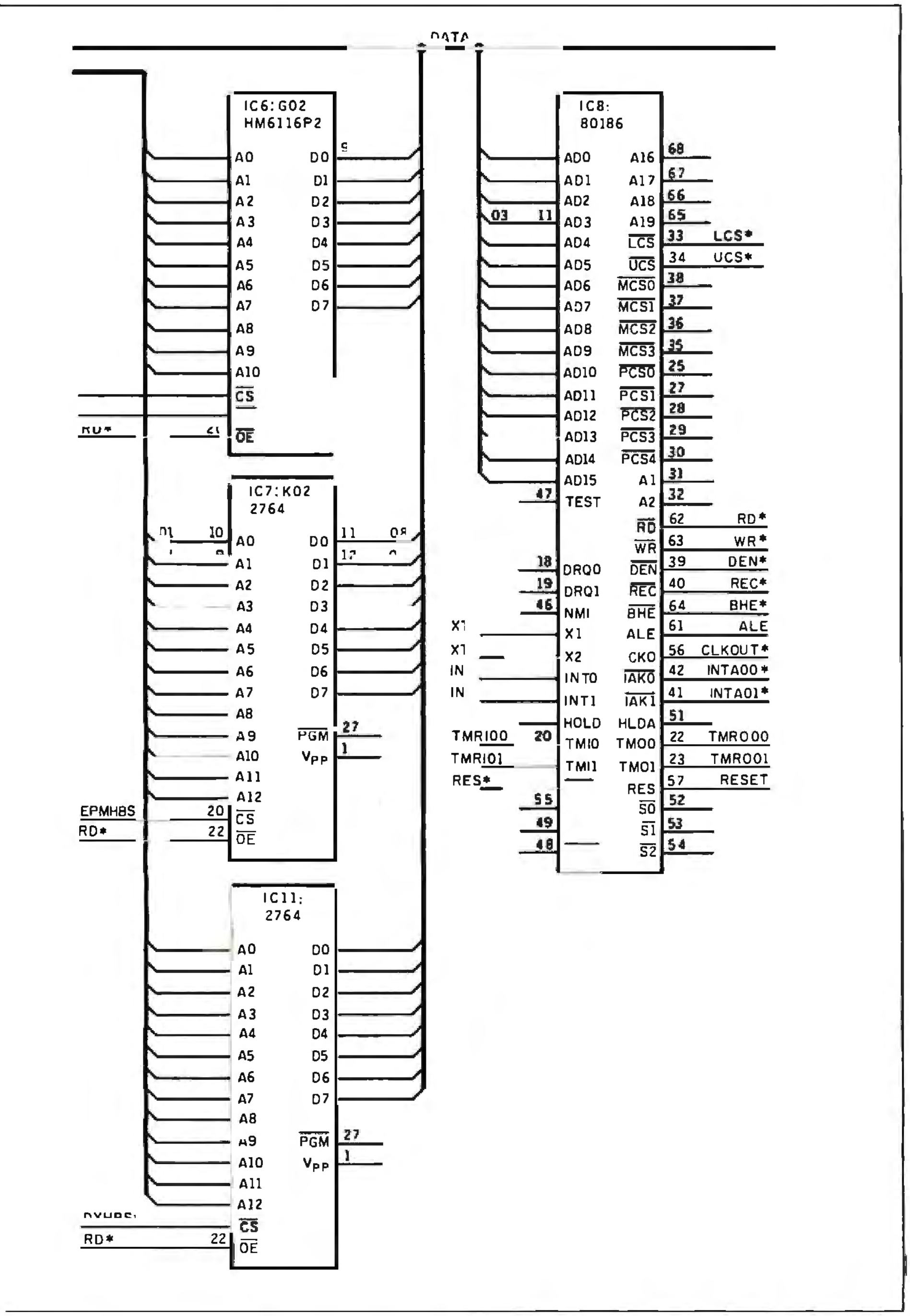


Figure 6: *A CADcompiler finished drawing, showing the added data bus lines.*



also yields a speed increase of two to four times that of the graphics modes of most printers. The limitation to rectangular shapes with leads on the sides becomes less of a problem with the tendency to use PALs instead of gates.

The primary drawing format is the "check drawing" that presents each device individually with all signal names listed on leads next to the corresponding pins (see figure 5). The devices can be placed on 8½- by 11-inch pages using the Arrange module, a graphics placement program that shows any two pages side by side on the screen. Figure 6 shows a finished CADcompiler drawing.

One significant advantage of the database-oriented CADcompiler system is that since the drawings are generated from the design, rather than the other way around, they need not be completed until the product is complete. This allows the drawing to be arranged for maximum clarity after its full content is known. This drawing modification cannot change the design, as might happen inadvertently with a drafting-oriented CAD system.

Engineering Change Control

A very important requirement for a digital CAD system is the ability to track engineering changes, especially during the development phase, if several boards are checked out concurrently but cannot be maintained at the same revision level. The Change module provides for comparison of two design files and generates a change report in the form of a netlist showing only the difference between the two files (see figure 7). This format has been used effectively for making the required wiring changes, and since it is simpler to implement than to write a change list directly, it encourages the maintenance of the design file.

An effective strategy is to maintain a copy of the design file at each revision level during development. It is then easy to generate a change list to update a board at any level to the current, or some intermediate, revision. This strategy is particularly effective if for some reason a change is removed or modified in one board prior to being incorporated into another. ■

Netlist Reports

The netlist report selection produces another menu for selection of a specific format. The diagnostic signal list (figures 1 and 2) provides a compact alphabetic list of the pins connected to each signal. This report also includes a single-pin list and an unused-pin list.

A variation of that list is available for a specific type of wire-wrap or multiwire board where the designators have been converted from device pin numbers to board pin numbers. Two other formats provide for interface to Redac and Telesis systems for automatic printed circuit layout. At least one should be close enough that a simple format-conversion program can interface with almost any automatic manufacturing process.

Drawing Reports

The CADcompiler uses character-mode graphics and produces all the entry forms and drawings using normal text combined with the graphics characters provided by most dot-matrix printers. This technique

ACKNOWLEDGMENTS

The author wishes to acknowledge the efforts of several people in the development of the CADcompiler program. Aaron Goldberg (Signatron Inc., Burlington, Massachusetts) developed the database file management system and the screen editor utilities. Rob Crooke (Custom Silicon Inc., Lowell, Massachusetts) developed the drawing and netlist report utilities and the hardware assembler module.

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Computer-Aided Routing of Printed Circuit Boards

An examination of Lee's Algorithm and possible enhancements

Stephen E. Belter

ALGORITHMS FOR THE computerized routing of traces on printed circuit boards have been evolving for the past 30 years. The rapid growth of the electronics industry and the availability of CAD programs for personal computers have moved the technology from mainframe computers in research laboratories directly to the desks of engineers.

All modern personal computers use PC boards to interconnect the various integrated circuits and components that compose most of their electronics. PC boards are usually constructed using an insulating glass-epoxy composite sandwiched between two layers of copper. Each copper layer is etched in such a way as to interconnect the appropriate leads of the components soldered to the PC board (see photo 1 and figure 1).

Designing the pattern of copper traces on a PC board can be a difficult task, as the connections cannot cross on a given layer. The process of determining the path a trace will follow between two points on a PC board is called routing. When routing is performed manually on a computer, the designer specifies where each line segment starts and ends for each trace on the board. If the CAD program supports interactive routing, the designer need only point to the two electrical networks to be connected, and the router will find and draw a path connecting the networks, if a path exists.

A so-called "auto-router" automates this process further by using a list of connections to be made and cycling the router through this list, connection by connection. This process can take anywhere from several minutes to several days to complete, depending on the board density, the number of copper layers on the PC board, the algorithms used, and the computer. In general, the resulting layout will have most, but not all, of the connections completed.

Completion percentages typically range from 60 percent to 90 percent, although examples of 100 percent completion are easy to contrive. Under normal circumstances, an operator must visually analyze the layout for traces that block the connections still to be made. These blocking traces are then moved, and new traces are run either manually or with the help of the interactive router.

In the best cases, only a few traces need to be moved to complete the board. In the worst cases, the majority of the traces placed by the auto-router must be "ripped up." Improved algorithms and the increased use of multilayer boards are resulting in a trend toward higher completion percentages. However, a claim of 100 percent completion is a trivial accomplishment if an unlimited number of layers is allowed.

While the examples cited here are for PC boards, routing algorithms are also applicable to the design of thin-film and thick-film hybrid electronics and the layout of integrated circuits. The rules are similar: Conductors may not cross on a given layer, and fabrication costs require that the number of layers be minimized.

Lee's Algorithm

Many commercial routing packages, including Wintek's smARTWORK, use a variation of a maze router. This approach was described by C. Y. Lee and is frequently called Lee's Algorithm. The PC board to be routed is represented in memory as a two-dimensional array, or matrix, of cells (see figure 2). Each cell is square and is centered on a grid point. All traces must start and end on a grid point, and traces can only be drawn horizontally or vertically between grid points. As a result, a cell is either empty or contains a conductor that connects to one or more of the four faces of the cell.

The goal, given a source cell and a target cell centered on grid points, is to find a path from the source to the target that does not cross an existing trace. The path must move only horizontally or vertically between grid points, and can change direction only at a grid point (see figure 3).

Accomplishing the goal involves two major phases. The first involves an ever-widening search in all directions from the source cell until the target cell is found. The search pattern is similar to the ripples in a pond that grow in circles around the spot where a pebble hits the water. The second phase retraces the path from the target cell back to the source.

If a path exists, the algorithm is guaranteed to find the shortest path. The

continued

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length of the path is measured using the Manhattan distance, which is defined as the sum of the horizontal and vertical movements.

Lee's Algorithm requires two data structures for the search—a first-in/first-out queue that holds the locations of cells waiting to be searched, and a flag array with one element for each cell on the PC board. This flag array is in addition to the storage structure used to hold the contents of the cells (conductor patterns) for the board. Each flag array element can take one of eight values: *source*, *target*, *unchecked*, *blocked*, *north*, *south*, *east*, or *west*. The elements of the flag array are initialized to the value unchecked. The queue is initialized to be empty.

Phase One

The algorithm proceeds as follows:

The breadth-first search begins by (1) storing the value source in the flag array at the coordinates of the source cell. Then it (2) checks the flag-array value at the coordinates of the target cell. If it is equal to source, the search is done; if not, it stores the value target at this location.

Next, it (3) places the coordinates of the source cell in the FIFO queue. While the queue is not empty, (4) it repeats steps 5 through 9 below. If the queue is found to be empty, the algorithm proceeds with step 10.

Step 5 gets the next set of coordinates from the head of the queue. This cell becomes the home cell for the purpose of steps 6 through 12. Then the algorithm (6) checks the flag-array element of the cell to the north of the home cell. If it contains the value target, the phase-one search is complete and the algorithm jumps to step 11. If the value in the flag-array element north of the home cell is any value other than unchecked, then the cell has already been checked and the algorithm can proceed with step 7.

If the value is unchecked, the cell must be checked for a conductor. If a conductor already occupies this cell, the cell cannot be used for a path from source to target, so the value blocked is stored into the flag-array element for the cell, and the algorithm proceeds with the next step. If the cell is empty, the value south is stored into the flag-array element, and the coordinates of this cell are appended to the tail of the queue. The flag value south will be used as the guide back to the source cell if the target cell is eventually found. This cell is added to the queue so that the neighbor cell will eventually be checked in the search for the target. Steps 7, 8, and 9 repeat this process for the cells east, south, and west of the home cell.

Step 7 checks the flag-array element of the cell to the east of the home cell. If it contains the value target, the phase-one search is complete and the algorithm jumps to step 11. If the value in the flag-array element east of the home cell is any value other than unchecked, the algorithm proceeds with the next step. If the value is unchecked, the cell is checked for a conductor. If a conductor already occupies this cell, the value blocked is stored into the flag-array element for the cell, and the algorithm proceeds with the next step. If the cell is empty, the value west is stored into the flag-array element, and the coordinates of this cell are appended to the tail of the queue.

Step 8 checks the flag-array element of the cell to the south of the home cell. If it contains the value target, the phase-one search is complete, and the algorithm proceeds with step 11. If the value in the flag-array element south of the home cell is any value other than unchecked, the algorithm proceeds with the next step. If the value is unchecked, the cell is

continued

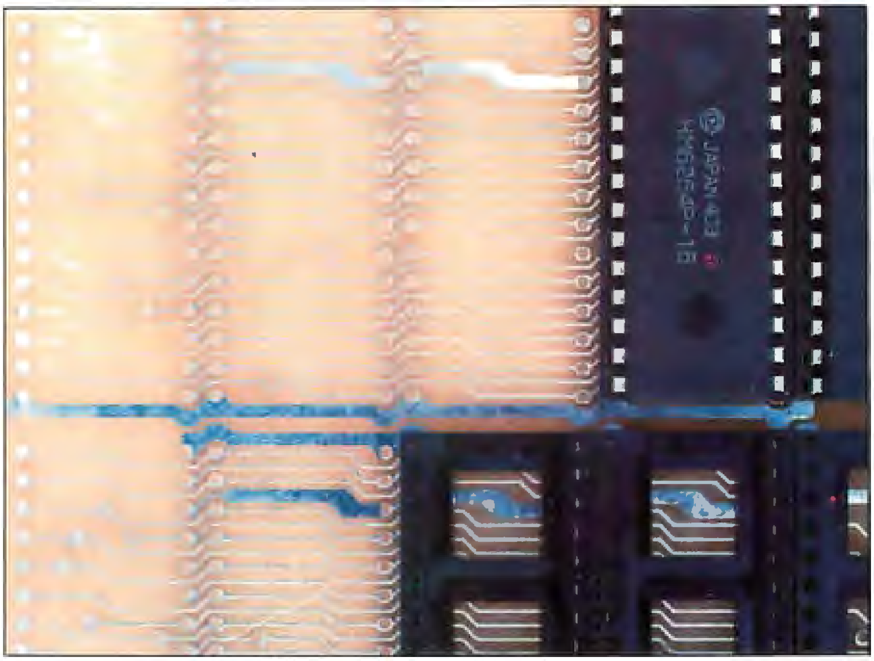

Photo 1: *A portion of a Wintek printed circuit board, showing the insulating substrate, copper traces, and components. The copper conductors have been covered with solder, giving them a silver color.*

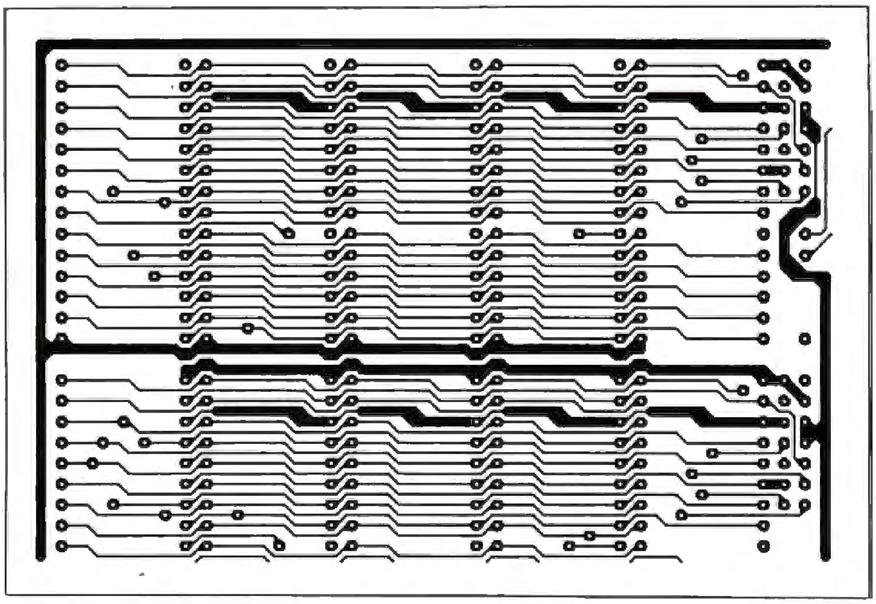

Figure 1: *A portion of the artwork used to create the printed circuit board in photo 1.*

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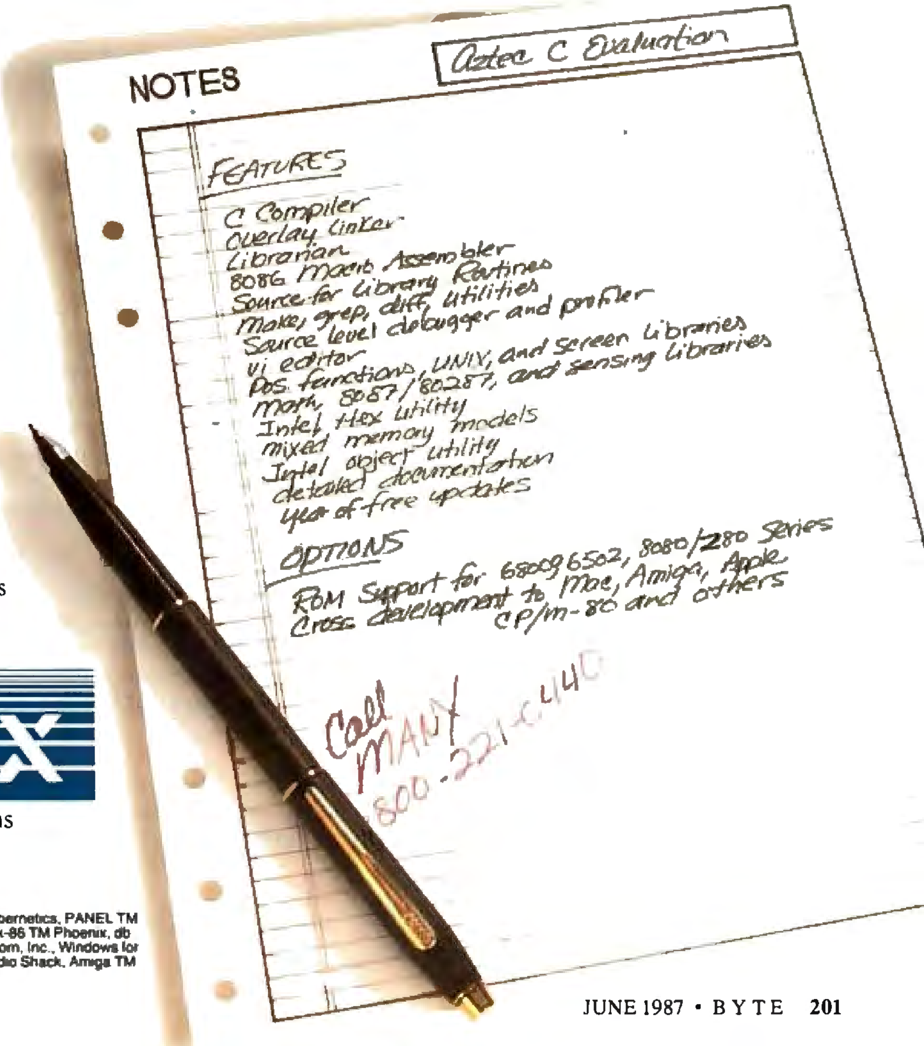


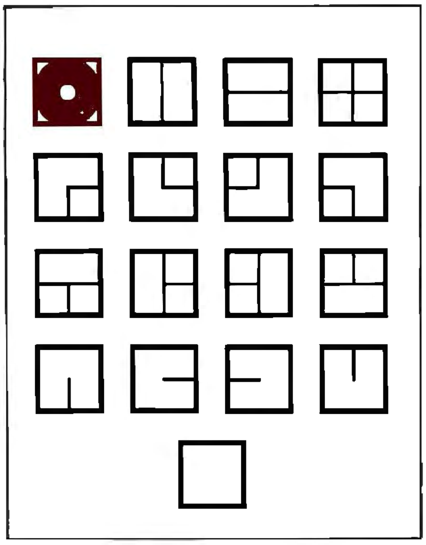


Figure 2: *All of the possible cell contents for the basic Lee's Algorithm. Component leads are normally soldered to pads (the circular conductor, also called vias); most traces will start and end at a pad. Pads may be used to connect traces on two different layers.*

checked for a conductor. If a conductor already occupies this cell, the value blocked is stored into the flag-array element for the cell, and the algorithm proceeds with the next step. If the cell is empty, the value north is stored into the flag-array element, and the coordinates of the cell are appended to the tail of the queue.

Step 9 checks the flag-array element of the cell to the west of the home cell. If it contains the value target, the phase-one search is complete, and the algorithm proceeds with step 11. If the value in the flag-array element west of the home cell is any value other than unchecked, the algorithm proceeds with the next cell from the queue (step 4). If the value is unchecked, the cell is checked for a conductor. If a conductor already occupies this cell, the value blocked is stored into the flag-array element for the cell, and the algorithm proceeds with step 4. If the cell is empty, the value east is stored into the flag-array element, and the coordinates of this cell are appended to the tail of the queue. The algorithm then loops back to step 4.

If the last step of phase one is reached (10), the queue of cells has been exhausted, and no path exists from source to target.

Phase Two

The second phase retraces the path found from target to source. So far, the algorithm has found the shortest path. All that remains is to (11) place the appropriate conductors in the cells of the PC board to establish a trace from the target back to the source. At this point, the home cell is adjacent to the target cell.

Now, the target cell found is modified to add a conductor from the center of the cell to the cell boundary adjacent to the home cell. And the home cell is modified to add a conductor from the cell boundary adjacent to the target to the center of the home cell.

Next, (12) the contents of the flag-array element of the home cell are examined. If it contains the value source, the algorithm is done; if not, it must contain one of the four values north, east, south, or west. The home cell and the cell in the indicated direction are modified to add a

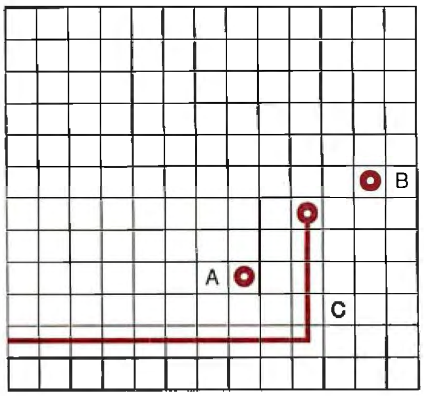


Figure 3a: *An example of using Lee's Algorithm to find a path from pad A to pad B. Trace C blocks the most direct route.*

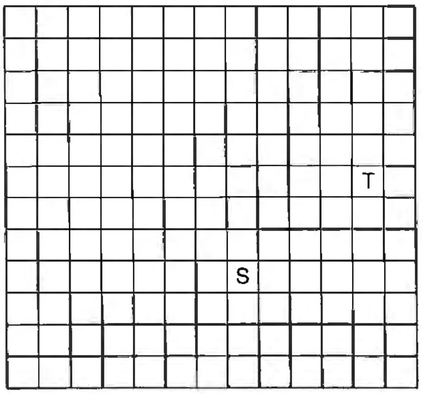


Figure 3b: *The flag array is shown pictorially as the search algorithm proceeds during the solution of the problem in figure 4. S and T represent source and target. Unchecked cells are blank. The coordinates of the shaded cell are in the FIFO queue.*

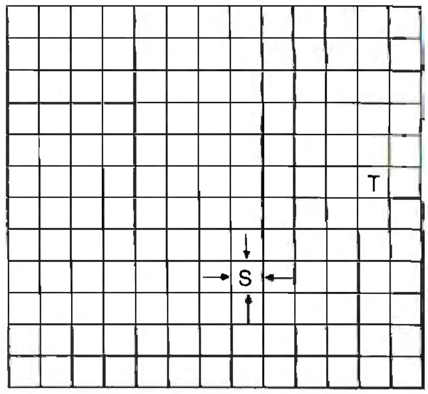
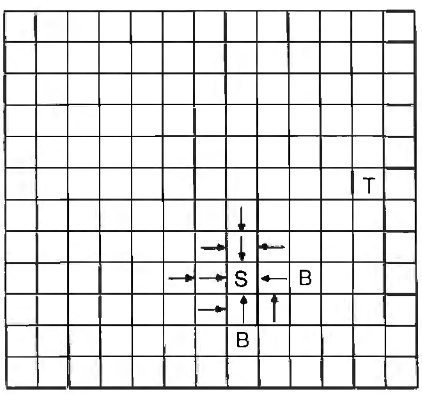
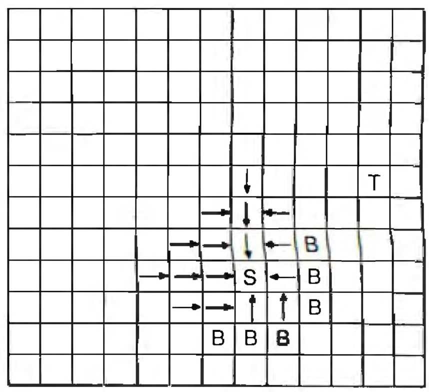


Figure 3c: *After following steps 4 through 9 once, the flag array now has four additional entries, and four sets of coordinates are in the FIFO queue. The arrows are used to represent the values north, east, south, and west.*



◀ **Figure 3d:** *The diamond-shaped search wavefront is a characteristic of Lee's Algorithm. By this point in the search, two cells that already contain traces have been found and have been marked as blocked.*

Figure 3e: *Four more blocked cells have been found. The coordinates for six cells are currently in the FIFO queue.* ▶



conductor between the cell centers.

Then, (13) the algorithm moves to the cell adjacent to the current home cell in the direction indicated by the home cell's flag-array element. The cell thus reached becomes the new home cell, and step 12 is repeated.

Enhancements to Lee's Algorithm

You could make a number of improvements in the algorithm. In many situations, the source and target cells will already be connected to one or more traces on the PC board before the router is invoked. It is usually desirable to find the shortest path between the source and target networks, rather than insisting on running a new trace between the source and target cells. This is easily accomplished by modifying the first two steps of the algorithm so that all cells electrically connected to the source cell are flagged as source, and all cells in the target network are flagged as target. Also, the coordinates of all cells in the source network are placed in the FIFO queue in step 3. The other steps remain the same.

The algorithm will find one route from source to target. While the procedure guarantees that there are no shorter routes, there will frequently be more than one route of the same length. In fact, there may be several hundred routes from source to target network with the same Manhattan distance. There are several criteria we can apply to choose among the shortest routes, such as minimizing the number of turns in the trace (turns introduce stress points, which are more likely to fracture) and maximizing the distance to other conductors (to reduce cross talk and avoid solder bridges).

One way to accomplish this task is to modify the search phase of Lee's Algorithm by replacing the north, east, south, and west values with a number indicating the distance back to the source cell. Then, during the retrace, the algorithm could examine the four cells surrounding the home cell for the cells with the shortest distance back to the source. When there are two or more having the minimum distance figure, we can apply the additional criteria to choose among the minimum-length paths.

As presented here, the algorithm allows only horizontal and vertical traces. Connecting two cells that are located at some diagonal distance with respect to each other can produce a trace with dozens of small "stair steps" (see figure 4). In addition, the assumption that only one trace can occupy one cell can impose severe restrictions on the density of a layout or the minimum distance between components. ICs, which have most of their pins wired in parallel (e.g., memory arrays), may suffer from the "walking jag" problem (see figure 5).

With care, Lee's Algorithm can be modified to allow the introduction of diagonal traces. For example, you can replace a cell holding an L-shaped trace connecting the north and east faces of the cell with a trace moving diagonally from the center of the north face to the center of the east face.

This diagonal cell offers several important benefits. You can now draw smooth lines at 45 degrees in addition to horizontal and vertical traces (see figure 6). The 90-degree junction of a horizontal and vertical trace can now be broken into

continued

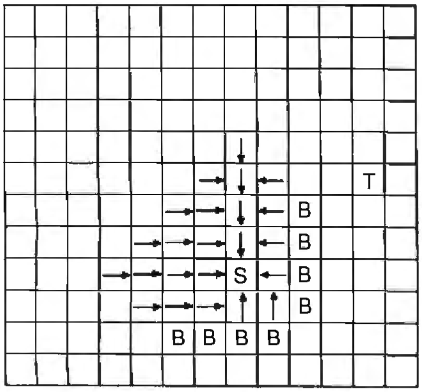


Figure 3f: *The search continues to the north and west, as trace C has blocked any further search to the south or east.*

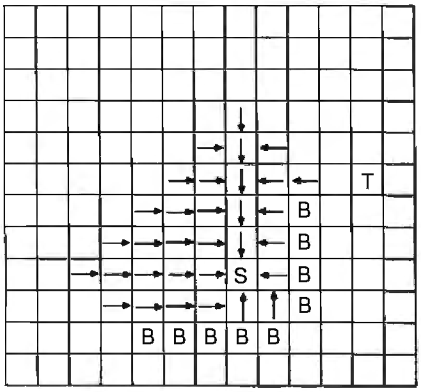


Figure 3g: *The algorithm has now found a path to the east again, passing over the upper end of trace C. There are now nine sets of coordinates in the FIFO queue.*

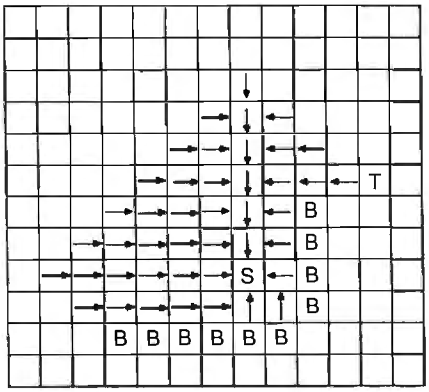


Figure 3h: *The search wavefront continues to expand and is now within one cell of finding the target.*

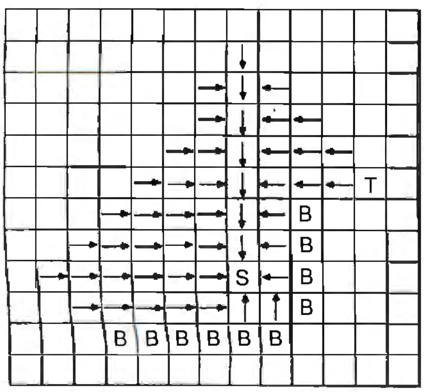
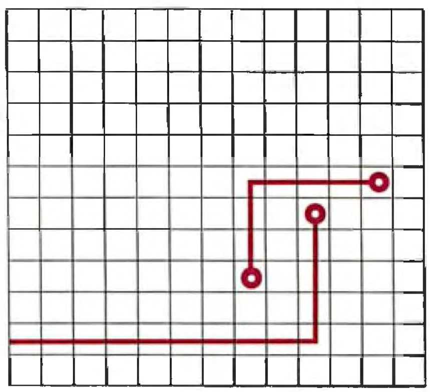


Figure 3i: *The flag array after the completion of the search phase. The home cell for step 11 is just to the left of the target (T) cell.*

Figure 3j: *The route found by applying Lee's Algorithm to the problem in figure 4.*



two 45-degree bends (reducing chance of stress fractures). Most importantly, you can allow two parallel diagonal traces in one cell. This eliminates the walking jag problem and allows the placement of memory arrays with only 1/10 inch between ICs.

The modifications to the algorithm re-

continued

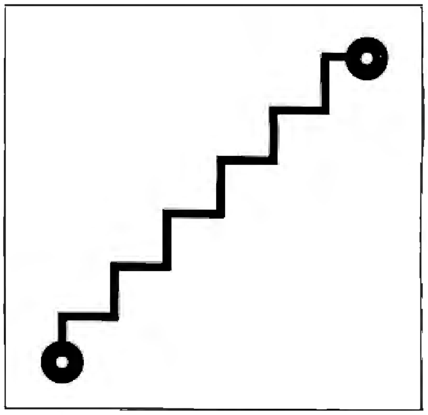


Figure 4: *Two diagonally placed cells with a "stair step" trace connecting them.*

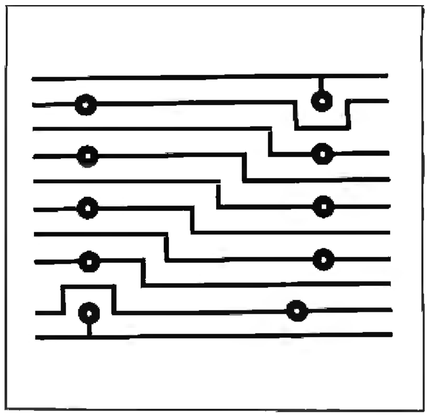


Figure 5: *An example of the "walking jag" problem, where two ICs have pins connected in parallel. The distance between the two columns of pads can be reduced by using diagonal traces.*

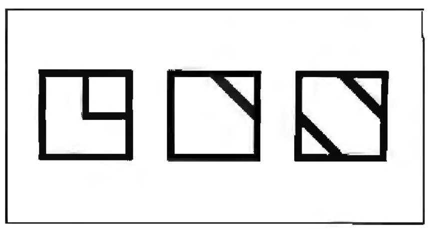


Figure 6: *Replacing an L-shaped trace in a cell with a diagonal trace allows the smooth construction of 45-degree traces. Using a double-diagonal cell allows two conductors to occupy one cell.*

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Keep in mind, Lee's Algorithm is not without its limitations.

quired to handle this "deadly" double diagonal are well beyond the scope of this article. Many special cases must be anticipated and handled, but the basic outline of the procedure remains the same.

Keep in mind that Lee's Algorithm as presented here only routes on one layer of the PCB at a time. Multilayer strategies are possible, and vias can be introduced to provide an electrical path between layers when required. (Vias are holes drilled through the circuit board, similar to the holes used to accommodate the pins of an IC.) The interior surface of the hole is plated with copper during manufacturing to provide an electrical connection.

Limitations

Using a 50-mil (0.050-inch) grid, Lee's Algorithm can be implemented as an interactive router on a personal computer. However, Lee's Algorithm is not without its limitations.

The time required to find a path between two points n cells apart is proportional to n^2. For small n, this time is short and not of practical concern. But for large n, the search can take minutes. As a result, some commercial products make use of several routing algorithms.

The storage required to support the algorithm includes space for both the FIFO queue and the auxiliary array (the flag array). This is in addition to the space required to hold the representation of the conductors on the PC board. Using 3 bits to hold the eight values in each element of the flag array, assuming a 50-mil grid, and allowing for a maximum board size of 10 by 16 inches, the flag array requires 24K bytes. This is well within reason for a personal computer-based program.

But when you use a 10-mil grid, execution time for the router jumps by a factor of 25 ($5n \times 5n$). Storage requirements for the flag array go from 24K to 600K bytes. Going to a 1-mil grid produces astronomical numbers. A route that took 3 seconds to complete with a 50-mil grid now takes 2 hours (3 seconds × 2500), assuming you could find a personal computer that will directly address 60 megabytes (just for the flag array). Obviously, routers that work with a grid finer than 50 mils use other algorithms.

Other Routing Algorithms

There are several other techniques that may be applied to the routing problem. Most fall into three or four broad categories. Each implementation is unique because of the data structures and heuristics implemented by the program authors.

A *channel router* alters the cell concept described for Lee's Algorithm. Instead of using small, fixed-size cells, the PC board is divided into large rectangles corresponding to the space between rows or columns of IC pins. These rectangles (or channels) are usually long and narrow; some can extend the length of the board. Each can hold several parallel traces.

The routing algorithm finds paths between source and target networks by assigning traces to channels, typically using vias to change sides of the board when moving from one channel to the next. One interesting characteristic of this procedure is that the ordering or location of individual traces within a channel is not fixed until the routing of all traces is complete. As a result, a trace can be pushed up or down within a channel as other traces are added to that channel.

A *line-probe router* takes an entirely different approach to the data structure used for routing. Instead of organizing the storage by using cells or rectangles, the line-probe router only stores vertical or horizontal lines. These lines correspond either to conductors already in place on the PC board or to other obstructions (e.g., the edge of the board).

To determine if a horizontal trace can be placed in a particular spot, the algorithm checks that the route is not blocked by vertical lines. Similarly, the location of a proposed vertical trace is checked against the existing horizontal conductors. With proper organization of the data, this check can occur very quickly.

The general strategy is to "probe" by constructing a sequence of line segments starting at both source and target points. When two segments from the two sequences intersect, a path from source to target has been found. A retrace procedure is then applied to draw the trace and insert the necessary vias.

While not guaranteed to find the shortest route, nor even guaranteed to find a route if one exists, both the channel and line-probe routers take much less storage and execute more rapidly than Lee's Algorithm on a small grid.

Other ad hoc algorithms are also widely used. For example, routing of ICs with

continued

many pins wired in parallel (e.g., the address and data pins of a memory array) may require special techniques to guarantee success. Routing of power and ground conductors or the use of separate power and ground planes may also require special handling.

Auto-routers

As mentioned earlier, an auto-router iterates through a list of connections to be made, using one or more of the algorithms discussed above to complete traces one at a time. Large, complex boards may require days to auto-route using sophisticated algorithms on mainframe or superminicomputers. Nonetheless, auto-router packages for personal computers are gaining widespread use.

An auto-router normally starts with a netlist: a list of all the electrical networks in a design, with all the sublists of pins that should be connected in each network. The netlist can be generated by hand (and frequently was 10 years ago), but the most common approach is to use a schematic-capture program. This approach eliminates transcription errors, although it does not eliminate errors in the schematic.

The auto-router reads this list and, using information specifying the location of each component, generates a wirelist. The wirelist is a pair-wise listing of source and target points that need to be connected. Each network in the netlist is analyzed to determine the minimum set of line segments required to connect each pin in the network. The line segments are chosen so that the sum of their lengths is as short as possible.

Once the wirelist has been constructed, each pair of points to be routed must be assigned to a layer of the PC board, and the routing order must be decided. A number of techniques are in common use, however, short routes are usually tried before long routes, and horizontal or vertical paths are routed before diagonal ones. Different routing algorithms may be used, depending on the relative locations of the two points to be connected.

The success of an auto-router, as measured by its completion percentage, depends on a wide variety of factors. These include board density, component placement, ratio of random to parallel connections, number of layers allowed, number of vias employed, the routing algorithms, and the ordering of the wirelist.

Market pressures are forcing the application of more sophisticated electronics across a wide spectrum of applications. The time allowed for design and testing continues to shrink. Fortunately, the emergence of low-cost CAD tools and the increasing computational power and storage available in personal computers is combining to give engineers and other designers the tools they need to meet the challenge. A program for aiding in the layout and routing of PC boards is one of these important tools. ■

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 Inquiry 21

Horror

Brace yourself.

Be prepared for some tales that'll make your flesh creep and your blood run cold.

The problem comes about in many ways. Inadvertent command error. System breakdown. Power source failure. Whatever.

The problem is data loss.

And it led to these true-to-life stories of unending horror that could make you start regretting every moment you forgot to back up that important data of yours.

Read 'em and weep…

Stories.

Once upon a time there was a guy, let's call him Joe, who set up shop in the market research business.

He had a very small office, one corner of which was set aside for his computer.

Then one evening Joe got a visit from the data-crash monster.

It happened like this.

When he worked on the computer, Joe kept his diskettes next to him... in a shoe box, on top of a covered trash bin which doubled as a table top until he could get around to finishing the furnishings.

Each night before he left, he put the shoe box away in the desk drawer.

Every night but one.

Nearing completion of his first major research project, one evening Joe went home without remembering to take the diskettes off the trash bin.

The cleaning people took his diskettes out with the trash.

Oh, Joe was able to duplicate it, all right.

In a mere three months.

Joe now backs up everything but the laundry marks on his shirts.

So the monster got discouraged and went on to other victims.

Kurt, a playwright, was working on the last act of his new play, which had been in rehearsal for six weeks. After various rewrites, Kurt was still agonizing over the right ending.

Two days short of opening night, Kurt finally came up with the ending he wanted. He sat down to his computer and cranked it out.

After a few hours, when it was just about finished, the phone rang. As he reached over to pick up the phone he somehow kicked the plug to the computer, and out of the socket it came.

(Kicking out plugs is one of the monster's specialties.)

Crash. That was the end of the ending.

Devastated because he knew he could never in a million years recreate it, he called the director and quit the show. The show never did open.

Finally, there's a horror story that actually happened to the writer of this copy.

I put together a compilation of idiomatic cliches once, with an eye to getting it published as a reference book.

In a move to another city I shipped some boxes ahead to be held by the hotel for my arrival.

Including one with the only copy of my book in it. Before my arrival it got lost in the shuffle.

Reconstructing the whole book was about as appealing as wrestling a jellyfish.

Scratch one book.

But if you think those horror stories are bad, you don't know the half of it...

Behind every horr
horror story wa

or story is another iting to happen.

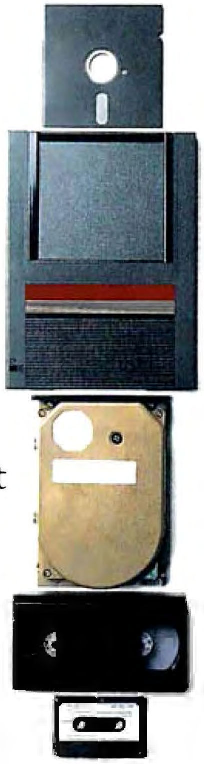
Never relax your guard when dealing with the data-loss monster. Even if you've done your backup.

He has a one-two punch, you see.

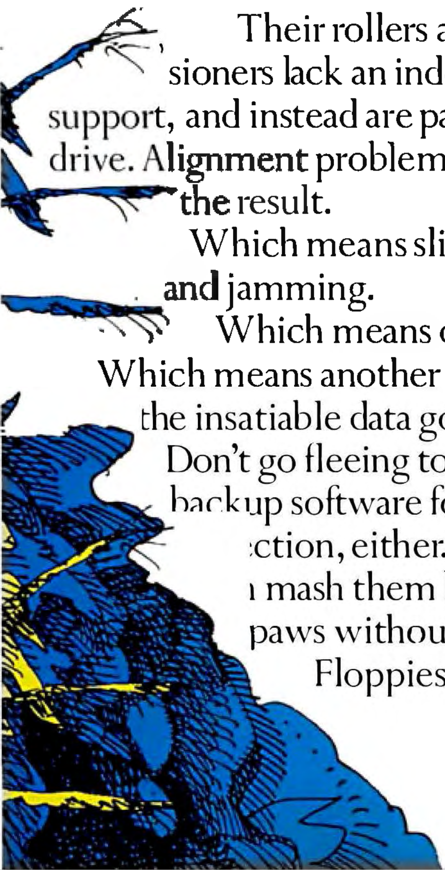
He not only mauls the data you *don't* back up, he can also rip to shreds data you *do* back up.

Because those hard disks you're backing up aren't the only things that can suffer data loss, you know.

The backup media itself can have data loss, as the following gruesome details will show.



Data cassettes and video cassettes have an Achilles' heel monsters thrive on.



Their rollers and tensioners lack an independent support, and instead are part of the drive. Alignment problems may be the result.

Which means slipping and jamming.

Which means data loss.

Which means another victory for the insatiable data gobbler.

Don't go fleeing to floppies or backup software for mass storage ction, either. The Cruncher n mash them between his paws without half trying.

Floppies are great for what floppies are for. Including even a little backup. But for backing up a lot of data, you'll not only get a tired arm slugging the things in and out of your PC, you'll get too much risk of crunching, crushing and creasing (deeds that data gremlins delight in perpetrating).

Imagine. You can even mess up your data by a simple fingerprint at the floppy's sausage-shaped opening. And if a fingerprint can mess things up, imagine what the big guy can do to your data with all his digits and limbs going at it.

Finally, some people are trying to outfox the monster by using a second hard disk that they only turn on when they need to use it.

That's like protecting your home with a burglar alarm that's not turned on all the time.

Turning on the second disk some of the time just means it's only at risk some of the time. It improves your odds, but you're still at risk.

And if that hard disk isn't the removable kind, fate could remove some of your data in a generalized problem like a fire at the office that could sabotage both your backup and main disk.

So what do you do, surrender?

No, you turn the page...

meets his match.

All good monster stories have happy endings where the beast gets his just desserts, and this story is no exception.

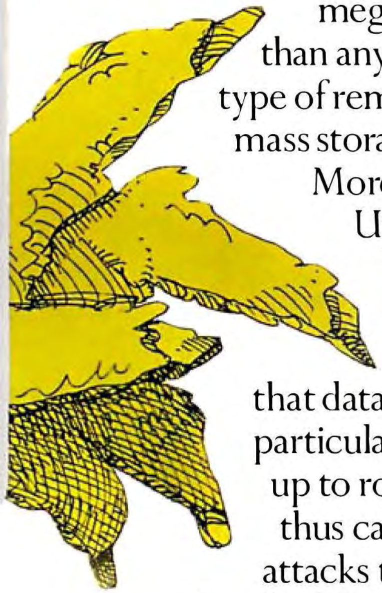
3M has figured out a way for you to exorcise the demons of data destruction.

Data cartridge tape.

An inexpensive, easy-to-use way to store lots of stuff in very little space.

A cartridge is only 5¼" tall (its little brother is only 3½") but it keeps the data-loss monster at bay better than anybody.

Data cartridge tape is less expensive than half-inch tape or the removable, rigid disk-based systems. And in fact offers a lower cost per megabyte than any other type of removable mass storage for the PC user.



More storage capacity, too. Up to 150 megabytes.

The tape itself is fully enclosed in a tough plastic shell that data-loss monsters find particularly frustrating. It stands up to rough handling, and thus can survive monstrous attacks that floppies can't.

You don't have to worry about data-loss problems from improper handling of the tape, because you don't handle the tape. It stays put in the cartridge.

The tape is further protected by a built-in metal plate that supports the rollers and tensioners. This precisely controls the tape alignment, preventing slipping and jamming of the tape — something which can cause data loss in cassettes. There's also a little protective "shutter door" that cassettes don't have, which closes over the tape when the cartridge is disengaged.

All of which pretty much does the data-loss monster in.

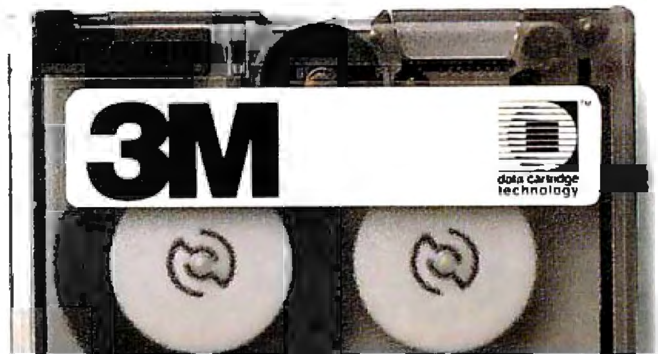
Leaving you with unequaled reliability, economy and convenience.

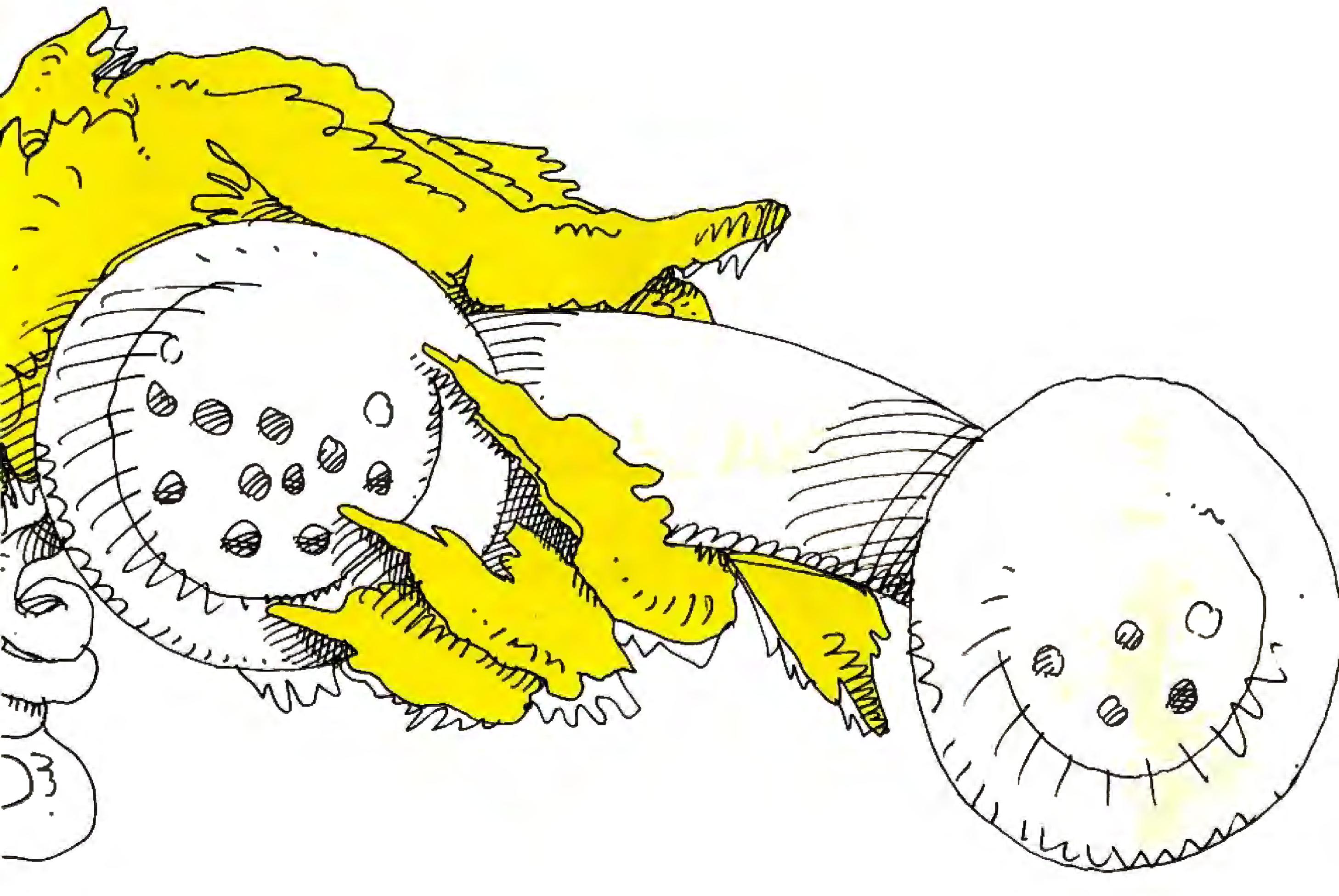
What more could you want in data backup? Not to mention data cartridge's other functions, such as archival storage, data-base distribution, software distribution, transaction logging, image storage, and data acquisition.

Finding the hardware isn't hard.

3M invented data cartridge technology to meet the needs of mass storage. And more and more manufacturers (over 150 at last count) are utilizing it in their designed-in cartridge drives and plug-compatible subsystems.

For a list of manufacturers who can answer your questions about data cartridge technology, turn the page.





(800) 423-3280
(And woe be to the monster.)

IGES

One answer to the problems of CAD database exchange

Ralph J. Mayer

IGES (INITIAL GRAPHICS Exchange Specification) has gained worldwide acceptance as the most popular method of moving data from one CAD system to another. IGES was developed in 1979 under the leadership of the National Bureau of Standards, whose goal was to facilitate the transfer of product definition data between different CAD systems. Version 1.0 of IGES was published as part of an ANSI standard in 1981. Version 2.0 was published in 1982, and version 3.0 in 1986.

Data transfer using IGES has been demonstrated at many trade shows, and the IGES organization has grown from its original three developers to a volunteer organization of over 600 people and over 100 companies and other organizations. IGES also has its detractors, however, who claim that it does not work as well as it should and that there are better alternatives. The controversy surrounding IGES is likely to continue as CAD users are only now beginning to appreciate the technical and management issues regarding database transfer.

Technical Overview

Designed originally to avoid problems encountered during the 1970s with the proliferation of direct translators, IGES uses the neutral file concept. Writing direct translators between four different systems requires 12 different translators (see figure 1). Adding a fifth system adds eight additional translators, and the number of translators continues to go up geometrically with the number of systems. Conversely, translation using a neutral file is done from one native format to the neutral file and then to another native format (see figure 2). For four systems, eight translators are required. Each system added will require only two more translators.

A side benefit of neutral files is that they can potentially be archived. Some companies in the aerospace industry, for example, need to keep CAD databases for 20 to 50 years. The IGES organization has a commitment to upward compatibility so that IGES files created today can be read by new CAD systems as they are developed.

IGES itself is just a document describing what should go into a data file. Developers must write software to translate from their system to the IGES format, or vice versa. The software that translates from a CAD system to IGES is called a preprocessor. The software that goes the other way (translates from IGES to a CAD system) is called a postprocessor (see figure 3). The preprocessors and postprocessors determine the success of an IGES translation.

Like most CAD systems, IGES is based on the concept of entities. Entities range from simple geometric objects, such as points, lines, and circles, to more sophisticated entities, such as dimensions, subfigures, and sculptured surfaces. Entities in IGES are divided into three categories: geometry, annotation, and structure. Geometry entities, such as lines, circles, and surfaces, define an object. Annotation entities include dimensions, notes, title block, and so forth that aid in visualization and documentation of the object. Structure entities consist of the various ways CAD systems combine other entities to make descriptions easier.

An example of a structure entity is a subfigure (also called a block, a cell, or a ditto in various CAD systems), which might be used to combine all the curves of a wheel into a single subfigure entity. You could place the subfigure entity four times on a drawing of a car without making four copies of all the individual entities that make up the wheel.

In its beginning, IGES was only defined in an ASCII, user-readable format using 80-character records. To create smaller files (IGES file sizes are typically 5 to 10 times the size of CAD native databases), a binary format and a compressed ASCII format have been defined, but the majority of IGES processors still only support the original ASCII form.

The files are divided into five sections: start, global, directory entry, parameter data, and terminate (see figure 4). The start section is just readable text at the start of the file used for documentation. The global section is 24 parameters of a global nature, such as the name of the file, its author, date of creation, units of measurement, precision of the numbers in the file, and so on. The directory entry (DE) section contains data that is common for each entity in the file, such as its type, color, line style, layer, views it's

continued

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visible in, and a transformation matrix used to position the entity in three dimensions.

The parameter data (PD) section contains specific entity information. For lines, it's the x,y,z endpoints; for surfaces, it's the x,y,z locations and definition vectors that describe the surface. There are two lines in the DE section for each entity, and one or more lines in the PD section for each entity. Since IGES files typically contain thousands of entities, these sections constitute the bulk of the file. The terminate section is a single line at the end of the file that contains the number of records (or lines) in each section.

The IGES document describes formats for about 50 different entities, many of which have alternate forms, resulting in about 150 possible formats. All entities have the same data defined in the DE section. They have unique formats for the PD section. The data in the PD section can range from the x,y,z values that define a point to hundreds of values that define a sculptured surface. Some entities contain text that is used in dimensions or notes on a drawing. Entities can also reference other entities, allowing you to build structures.

The entities in version 1.0 of IGES were basically wire-frame entities and some surfaces, typically those found in the CAD systems of the late 1970s. IGES has grown since then, and version 3.0 includes not only additional surfaces, but entities for specific applications such as finite element modeling (FEM), electrical diagrams, printed circuit board design, piping, and architectural design. Version 4.0, which is due in 1987, will also support solids. In general, IGES tends to be a superset of the data found in existing CAD systems.

Current Status

IGES is supported by over 30 CAD vendors. It is generally the first method attempted by developers trying to move CAD data from one system to another. However, it has not lived up to some expectations, although many of those expectations were unrealistic. The expectation is that a user can take any CAD file, translate it into IGES, read the IGES file into another CAD system, and have 100 percent of the data transferred, including resolution of system differences. In real life some transfers are 100 percent, some are still zero (i.e., one or more translators failed), and most lie somewhere in between. It is difficult to give an average figure since the success rate depends on the IGES processors used and the types of entities in the file to be translated.

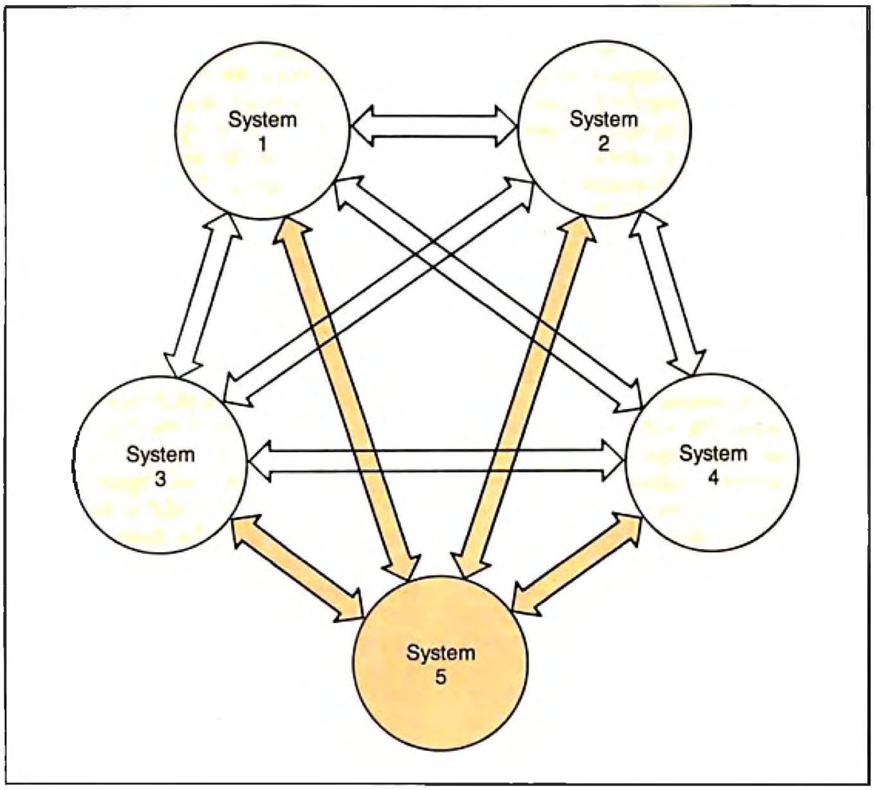

Figure 1: *Writing direct translators between four different systems requires 12 different translators. Adding a fifth system adds eight additional translators, and the number of translators continues to go up geometrically with the number of systems.*

The quality of IGES processors varies widely. Some processors handle surfaces and complicated structures, whereas others handle little more than lines, points, and circles. Some processors are flexible and have options to facilitate reading files from different types of systems. Other processors can read only the files they output. Obviously, some of the success depends on the type of systems; two mechanical three-dimensional systems, for example, should have more in common than a solids system and a two-dimensional system, or a mechanical CAD system and an electrical CAD system.

Most IGES processors, however, do handle points, lines, and circles. Since these three entities constitute the majority of any CAD database, you generally get something to view—perhaps only part of the original drawing. Support for other entities varies widely. Unfortunately, there is no way to know what will happen in advance. Some entities may be missing; other entities may be modified, and the only way to be certain is to run fairly exhaustive tests.

After the file has been transferred, you must evaluate the IGES translation itself. A good procedure is to create three types of test files. The first test consists of simple parts—lines, points, and circles. These parts provide a baseline of what works. The second test is a grid. Make a series of boxes and in each box put one entity, such as a line, a circle, or a text string. This test makes it easy to see which entity types are successfully transferred and which entities are missing. The third test uses a normal production part. Although using "real" data is best, it is also the most difficult to evaluate.

The most important method of evaluating an IGES transfer is to compare two plots—one from before the transfer and the other from the system it was transferred to. This is best done on a light table and is easier to evaluate if the plots are in different colors. Another method is to list out positions and counts of entities on the two systems to check that all the data is transferred and is in the same place. You should also try manipulating the data—edit text strings or dimensions, scale views, and move some of the geometric objects. Curves can be tested by creating a series of parallel lines that intersect the curve. The intersection points of the lines and the curve can be calculated on both systems and should be equal. Similarly, surface transfer can be evaluated by using parallel planes.

Many of the problems with IGES are caused by the way in which it is implemented. Each CAD developer implements its own IGES processor, and some simply do a better job than others. After all, the IGES organization is a voluntary one, and developers implement as much (or as little) of the specification as they see fit. Because of the large variety of data defined in IGES, no developer supports even close to all of the specification; in fact, the majority probably support less than half. To make matters worse, the problem is compounded by inevitable differences in interpretation and even bugs in software.

Also a problem is finding an agency to certify IGES processors. The National Bureau of Standards runs the IGES organization, but its charter prohibits it from any action that would smack of certification. And in light of current legal issues, no standards organization wants to say that a company's product does or does not meet a particular standard. Instead, the IGES organization is working with the Society of Automotive Engineers (SAE) to develop a validation program. Under the program, the SAE will certify that an IGES processor works as well as the developer claims. The program is scheduled to start this summer. The test data used for it will be in the public domain and available for any IGES user or developer interested in testing an IGES processor. Meanwhile, IGES implementation is dependent on the developers, who are not eager to implement IGES.

Yet there are some organizations trying to bring order into the confusion surrounding IGES. These are the large CAD users who want IGES to succeed. Prominent among them are the U.S. Navy, General Motors, Boeing, Pratt and Whitney, Hughes Aircraft, and the Department of Energy. These companies or departments have issued a simple edict: Support IGES or we won't buy your CAD system.

Alternatives

Even though the need to do CAD transfer is great, IGES has not been a perfect answer, and a number of alternatives—each with its own strengths and weaknesses—exist or are planned.

The first alternative is a direct translator, which goes through only one translation (IGES goes through two) and is not limited by IGES if the two CAD systems sharing data have capabilities not supported by IGES. However, a direct translator is usually written by one CAD developer to work with another developer's system, so there may be a lack of knowledge about at least one system. This knowledge can be obtained (often by reverse engineering) but is frequently incomplete. IGES translators, on the other hand, are usually written by the developer of the CAD system. The developer has full knowledge of that system and is in a position to easily keep pace with changes and improvements in it. Nonetheless, direct translators will continue to prosper as they satisfy specific market niches not met by IGES.

The second alternative is an external database format such as DXF (from AutoCAD) or SIF (from Intergraph). External formats are created by many CAD vendors to provide a way for their users to access the CAD database. The external database format is generally similar to the vendor's internal database format but is designed for ease of access and is unlikely to change. These formats are primarily created for users who write specialized applications. Mostly due to marketing clout, some of these external formats are sometimes considered "standards."

The disadvantage of these external formats is that they tend to be parochial. If the CAD system does not support a particular entity, then in most cases its external format doesn't contain it either. For example, AutoCAD, and by extension DXF, does not have a dimension entity or a spline entity. Inasmuch as most CAD systems do have dimensions and spline entities, that data would be lost using DXF as an exchange format. An industrywide standard such as IGES defines virtually all the data types created by any CAD system.

A third possible alternative to IGES is Specifications du Standard D'Echange et de Transfert (SET), a neutral file format that contains essentially the same data types as IGES. SET was written by Aerospatiale, the French aerospace company, which has made sure that all the translators work together. The main advantage of SET is its file format, which is much more compact than IGES.

For example, consider the sample IGES file discussed on page 212; it contains a dimension entity that actually consists of six entities (the dimension entity, the text entity, two leader entities, and two extension line entities). These six entities take up considerable space (1840 bytes) and require a lot of processing time to create and decipher. SET, on the other hand, uses the concept of blocks (equivalent to IGES entities) and subblocks. A dimension block in SET contains the data found in the IGES DE section, along with five subblocks containing the text, two leader lines, and two extension lines. Aerospatiale claims that this arrangement results in both substantially smaller files

continued

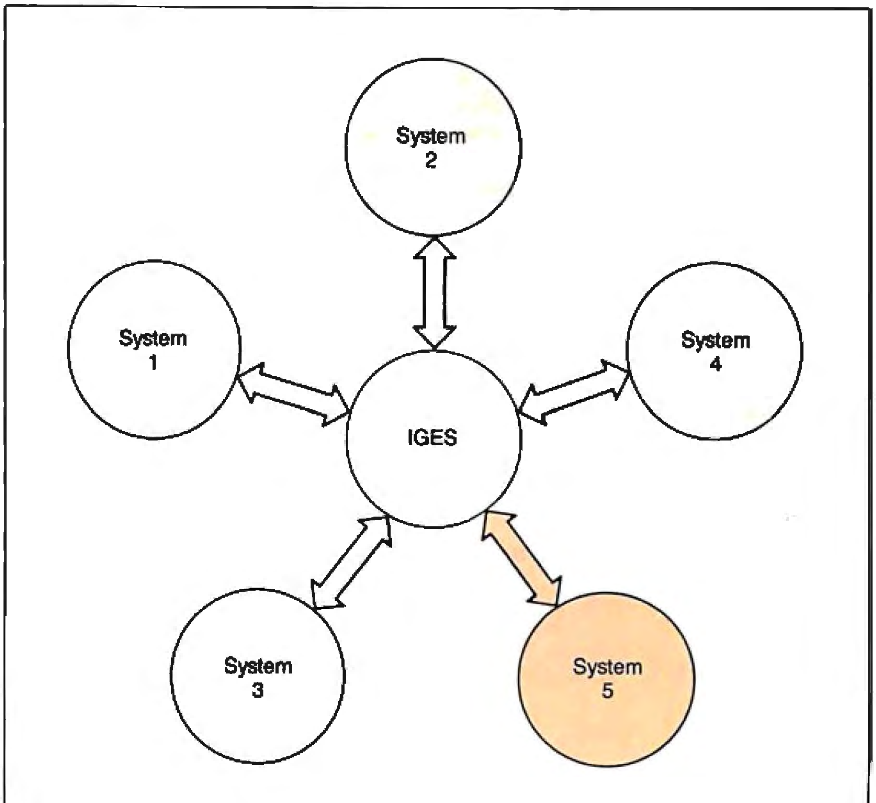

Figure 2: *Translation using a neutral file is done from one native format to the neutral file and then to another native format. For four systems, eight translators are required. Each system added will require only two more translators.*

A Sample IGES File

In the sample IGES file (see listing A), five sections are defined by an S, G, D, P, or T in column 72. The start section for this file is contained in lines 1 and 2, the global section in lines 3 through 6, the DE section in lines 7 through 48, the PD section in lines 49 through 75, and the terminate section in line 76. The global section contains information on the processor that generated the file, that the file adheres to IGES version 3.0, that the part is measured in inches, plus other values.

The file contains 21 entities. Entity 1 has its DE section on lines 7 and 8, and its PD section on line 49. The number 406 present on all three lines identifies it as a property entity. The other entity types in the file are: 410 for view entity, 116 for point, 100 for arc, 106 for copious data (used for dimension extension lines), 214 for leader arrow (used for dimension leader lines), 212 for general note (or text), 216 for linear dimension, 110 for line, and 404 for drawing. The data stored in the sample file represents a rectangle from (1, 1) to (3,2) with a circle of radius 0.2 at its center and a dimension on its top edge (see figure A).

To understand a little more about the structure, examine line 7. The 1 following the 406 indicates that the PD section for this entity is at PD:1 (or line 49). Similarly, in line 49 the 1 in column 71 (just before the P) indicates that the DE section for this entity is at DE:1 (or line 7). Other entities have corresponding values. Looking at the entity content, examine the line entity defined at DE:29 and 30, PD:21 (lines 35 and 36). The values from left to right in the DE section have the following meaning (note that the blank columns are equivalent to zeros):

110	Line entity
21	PD data is on line PD:21
Blank	No structure
1	Line font 1, which is sold
0	Is on level (or layer) □
3	Is only visible in the view defined at DE line 3
Blank	No transformation matrix
Blank	No label display
0	Status is 0
D 29	DE line 29
110	Line entity (again)
2	Line weight is 2
5	Color 5, which is yellow
1	Entity has one line of PD data
Blank	Form 0
Blank	Not currently used
Blank	Not currently used
Blank	No label
Blank	No subscript
D	30 DE line 30

The PD values have the following meaning:

110	Line entity
3.0	X1
2.0	Y1
0.0	Z1
3.0	X2
1.0	Y2
0.0	Z2
0	No associated entities
0	No properties

A very different type of entity is the linear dimension at DE:25 through 26 and PD:16. The DE data will be equivalent to that of the line entity, but its PD data is defined as follows (the other entities have their data defined in similar ways):

216	Entity type is linear dimension
17	DE value of general note entity with dimension text
15	DE value of first leader arrow entity
13	DE value of second leader arrow entity
11	DE value of first copious data entity with dimension extension line
9	DE value of second copious data
0	No associated entities
0	No properties

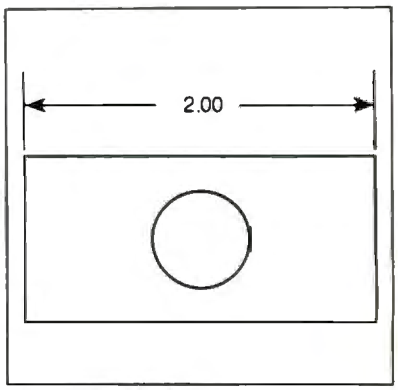

Figure A: *Drawing from the sample IGES file.*

Listing A: *A sample IGES file.*

```
THIS IGES TEST FILE WAS GENERATED BY ADRA SYSTEMS INC.                 S      1
FOR BYTE MAGAZINE                                                      S      2
1H,,1H;,,15HADRA IGES DEMO[,56HADRA SYSTEMS CADRA-II IGES REV 1.0DEVELOPG      1
MENT          ,16HIGES VERSION 3.0,32,8,24,8,56,,1.000000,1,4HINCH,3,  G      2
0.030000,13H870219.120500,5.000000E-04,8.507059E+37,17HCADRA-II OPERATORG      3
,13HCADRA-II SITE,4,0;                                                 G      4
     406       1                       0                           10300D      1
     406               0       1      15                               D      2
     410       2                       0                           10100D      3
     410               0       1                                       D      4
     116       3               1       0       3                      0D      5
```

```
     116       2       5       1                                           D       6
     100       4               1       0       3                          0D       7
     100       2       5       2                                           D       8
     106       6                       0                              10100D       9
     106               0       2      40                                   D      10
     106       8                       0                              10100D      11
     106               0       2      40                                   D      12
     214      10                       0                              10100D      13
     214               0       2       2                                   D      14
     214      12                       0                              10100D      15
     214               0       2       2                                   D      16
     212      14                       0                              10100D      17
     212               0       2                                           D      18
     216      16               1       0       3                        100D      19
     216       2       5       1                                           D      20
     116      17               1       0       3                          0D      21
     116       2       5       1                                           D      22
     116      18               1       0       3                          0D      23
     116       2       5       1                                           D      24
     116      19               1       0       3                          0D      25
     116       2       5       1                                           D      26
     116      20               1       0       3                          0D      27
     116       2       5       1                                           D      28
     110      21               1       0       3                          0D      29
     110       2       5       1                                           D      30
     110      22               1       0       3                          0D      31
     110       2       5       1                                           D      32
     110      23               1       0       3                          0D      33
     110       2       5       1                                           D      34
     110      24               1       0       3                          0D      35
     110       2       5       1                                           D      36
     406      25                       0                              10300D      37
     406               0       1      15                                   D      38
     406      26                       0                              10300D      39
     406               0       1      16                                   D      40
     404      27                       0                                101D      41
     404               0       1                                           D      42
406,1,3HTOP,0,0;                                                          1P       1
410,1,1.000000,0,0,0,0,0,0,0,1,1;                                         3P       2
116,2.000000,1.500000,0.0,0,0;                                            5P       3
100,0.0,2.000000,1.500000,2.200000,1.500000,2.200000,1.500000,            7P       4
0,0;                                                                      7P       5
106,1,3,0.0,1.000000,2.000000,1.000000,2.000000,1.000000,                 9P       6
2.874256,0,0;                                                             9P       7
106,1,3,0.0,3.000000,2.000000,3.000000,2.000000,3.000000,                11P       8
2.874256,0,0;                                                            11P       9
214,1,0.156000,0.062061,0.0,3.000000,2.724256,2.307130,                  13P      10
2.724256,0,0;                                                            13P      11
214,1,0.156000,0.062061,0.0,1.000000,2.724256,1.568844,                  15P      12
2.724256,0,0;                                                            15P      13
212,1,4,0.582286,0.156000,1,1.570796,0.0,0,0,1.646844,2.646256,          17P      14
0.0,4H2.00,0,0;                                                          17P      15
216,17,15,13,11,9,0,0;                                                   19P      16
116,3.000000,1.000000,0.0,0,0;                                           21P      17
116,3.000000,2.000000,0.0,0,0;                                           23P      18
116,1.000000,2.000000,0.0,0,0;                                           25P      19
116,1.000000,1.000000,0.0,0,0;                                           27P      20
110,3.000000,2.000000,0.0,3.000000,1.000000,0.0,0,0;                     29P      21
110,1.000000,2.000000,0.0,3.000000,2.000000,0.0,0,0;                     31P      22
110,1.000000,1.000000,0.0,1.000000,2.000000,0.0,0,0;                     33P      23
110,1.000000,1.000000,0.0,3.000000,1.000000,0.0,0,0;                     35P      24
406,1,7HDRAWING,0,0;                                                     37P      25
406,2,5.000000,5.000000,0,0;                                             39P      26
404,1,3,0.0,0.0,0,0,2,37,39;                                             41P      27
S      2G      4D      42P      27                                         T       1
```

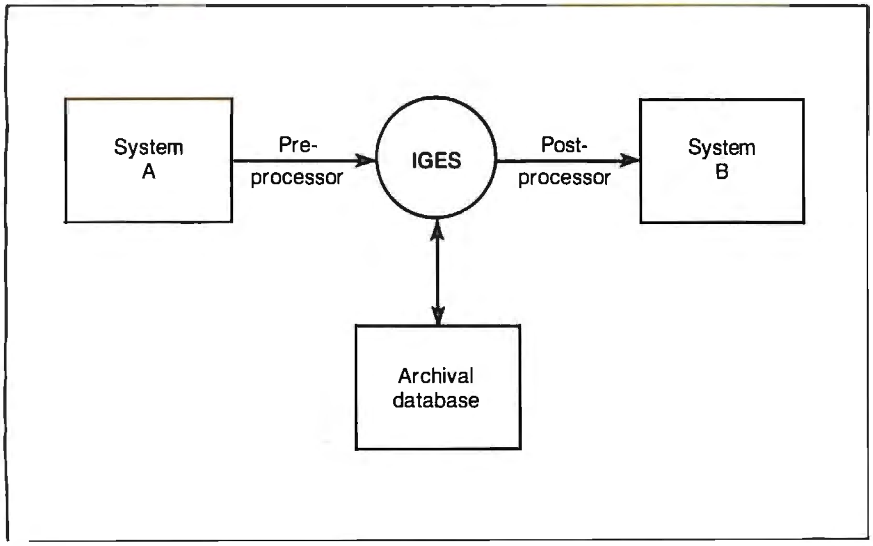

Figure 3: *The software that translates from a CAD system to IGES is called a preprocessor. The software that goes the other way (translates from IGES to a CAD system) is called a postprocessor.*

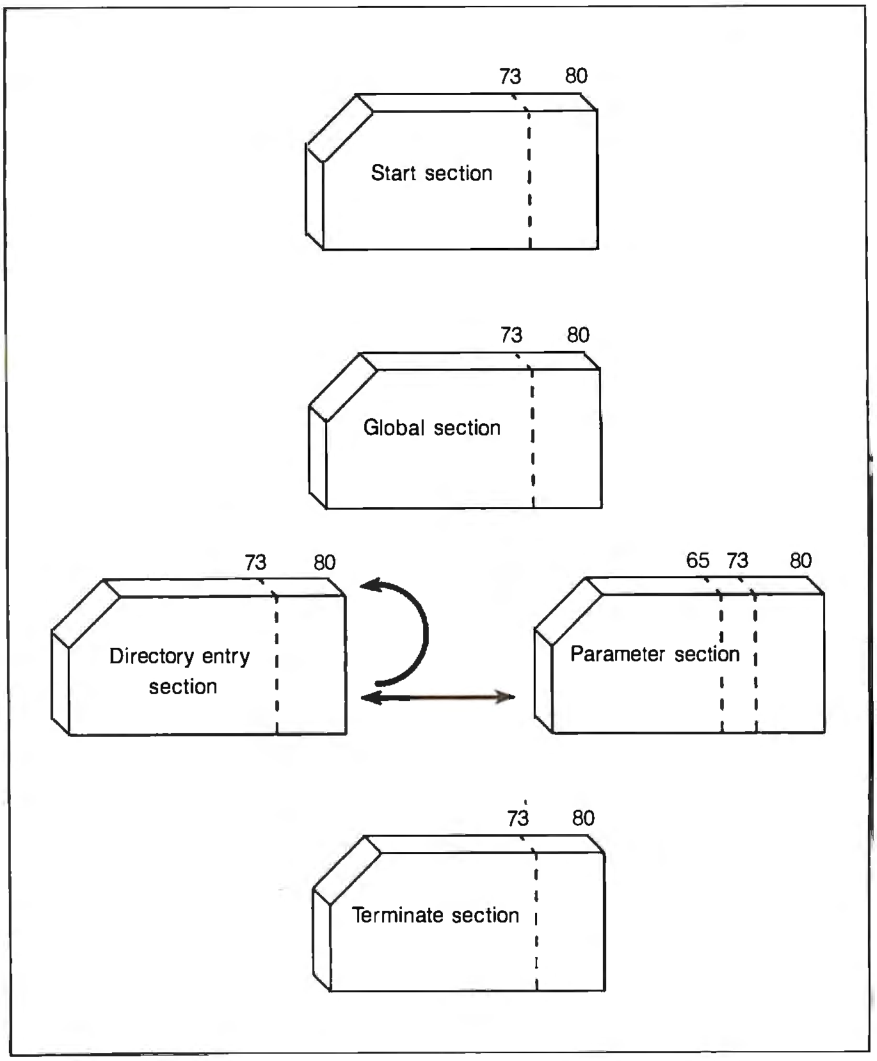

Figure 4: *The files are divided into five sections: start, global, directory entry, parameter data, and terminate.*

and substantially less processing time than in IGES. For a single dimension, the size of an IGES file can be seven times that of a SET file. The concept of blocks and subblocks is technically superior to the IGES method of using just entities. (IGES was based on CAD systems of the 1970s, which used only entities.)

SET is not currently supported by any U.S.-based CAD vendor. However, it is a French national standard and has been proposed as both a European and an international standard. International politics will determine whether SET will ever become a realistic alternative in this country.

Future Alternative

A future alternative to IGES is the Product Data Exchange Specification (PDES) being developed by the IGES organization. PDES will go beyond IGES's lines, circles, and dimensions entities to define a more conceptual model. Parts will be based on solids and defined in terms of features such as holes, flanges, or ribs. Instead of dimensions, PDES will define a tolerance envelope for the part to be manufactured. PDES will also contain nongeometric information such as the materials to be used, manufacturing processes, costs, and suppliers. PDES will be a complete computer model of a part.

PDES is intended for applications such as mechanical, electrical, and AEC (Architectural and Engineering Construction) drawings, as well as manufacturing. The development process includes applying information-modeling techniques to each application and finding the minimal set of conceptual data required by all applications. Then a data representation will be used to store the information in a three-level architecture: the application layer, the conceptual (or logical) layer, and the physical layer. This resulting data exchange format will be much more sophisticated than IGES.

Indeed, PDES is an ambitious undertaking. Even though a first draft is scheduled for late 1987, PDES translators are unlikely to be available until the 1990s. It is clearly a future-oriented file format meant to work with more sophisticated CAD systems that use solids, features, and maybe even artificial intelligence.

In the meantime, the IGES organization has made testing translators its highest priority. Although the quality of IGES processors has improved over the years, the SAE validation program promises to accelerate improvements. And with the pressure that's being applied by the Department of Defense and some of this country's largest corporations, the success of IGES translation should approach 100 percent. ■

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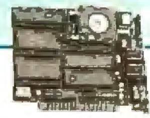

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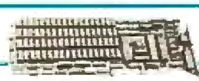

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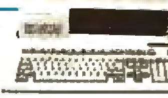

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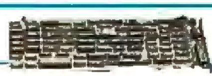

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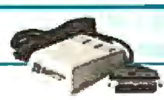

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CAD for Building Chips

Silicon compilers and the automated building of VLSI circuits

Steve Trimberger and Jim Rowson

A SILICON COMPILER IS a CAD program that translates a high-level description of complex circuits into the artwork needed to fabricate a semiconductor integrated circuit chip. The high-level description that we use depends on the function we wish to build and on the capabilities of the silicon compiler.

We can compare a silicon compiler to a software compiler. A Pascal compiler translates a function in the high-level Pascal language to machine code that implements that function. The compiler can optimize its output to produce fast code that uses memory efficiently. Silicon compilers also can optimize their output to improve the speed and size of the resulting chip.

There are many programming languages, each targeted to solve a particular kind of problem and each with a different specification language. Similarly, there are different kinds of silicon compilers. We will look at some common silicon compiler types and explain their importance in the development of new chip technology.

Impact of Silicon Compilers

Silicon compilers differ from programming language compilers in two important ways. First, a chip is two-dimensional. We lay out circuit functions on a planar surface, whereas software generates a one-dimensional sequence of instructions. The extra dimension of silicon makes good optimization difficult. The second major difference is the physical nature of the communication. In software, moving numbers requires no additional space. On an integrated circuit, every signal travels on its own wire. The wire takes space, and long wires contribute to long delays. On a chip, we pay a heavy penalty for using a value far from where we compute it. Silicon compilers tend to restrict the flow of data to make efficient chips.

The time savings from using a silicon compiler can be enormous, reducing the development time of a new IC from years to days. Like a software compiler, the silicon compiler guarantees correct interaction among the parts of a complex circuit, eliminating a whole class of potential errors.

The same specification to a silicon compiler can be used to build a better chip when the chip-making technology improves, just as a Pascal program can be recompiled and used on new, faster computers.

Compilers, whether software or silicon, are productivity-enhancement tools. They help you in two ways: They help raise the level of description so that a small amount of specification provides a large amount of functionality, and they make modification easier by automating the reimplementation of a project.

Effect on Personal Computers

As ICs become more complex, their design cost becomes a greater fraction of a chip's total cost. Silicon compilers reduce the system design cost, so the chips themselves are cheaper. More importantly, silicon compilers speed the design process, so new products become available sooner.

As a further benefit, as the technology improves, the same specification for a compiler can be used again with the new technology to instantly provide the next generation of faster, cheaper machines.

Types of Silicon Compilers

There are three main types of silicon compilers: those targeted to memories, those targeted to datapaths, and those targeted to general logic and state machines. The output code that a silicon compiler generates can be targeted to different kinds of semiconductor implementation (CMOS, HMOS, and so on), just as Pascal compilers generate code for different machines.

Silicon compilers tend to excel in one or more of three distinct areas: memory logic, multibit logic, and arithmetic and single-bit control type logic. The most popular compilers have specialized in one of these areas.

Software compilers tend to be classified mostly by input language and to a lesser degree by processor. However, the big difference between silicon compilers is how their outputs are implemented in silicon, with the differences in specification being largely a result of their implementation style or layout.

You can classify software compilers in

continued

Steve Trimberger is manager of advanced development at VLSI (1109 McKay Dr., San Jose CA 95131). Jim Rowson is manager of design technology at VLSI. Both received Ph.D.s in computer science from Caltech.

many ways. One useful way is by the level of abstraction in the input language—assembly language, procedural language, or object-oriented language. Another useful differentiation is how they are implemented—interpreter, compiler, or optimizing compiler. Similar methods classify silicon compilers. One method is to look at the layouts generated by the compilers (their implementation) for similarities. There are three broad classifications: regular array compilers, partially regular array compilers, and nonregular compilers.

Regular array compilers need very little specification because of the high degree of uniformity in their final output. A RAM compiler is an example. Partially regular array compilers take advantage of some repetitive structure in both their output and their specification language. A datapath compiler is an example of this type. Nonregular compilers need a powerful specification language, since every function must be specified by the designer. A state machine compiler is a nonregular compiler.

Because of their uniform nature, regular array compilers most efficiently use the area on the chip, with partially regular array compilers second and nonregular compilers last.

Regular Array Compilers

A regular array compiler implements functions by connecting many identical cells in a two-dimensional rectangular array. This core array usually requires some peripheral logic of replicated cells of another type. The spatial organization of identical-cell, rectangular-array circuits limits the communication of the cells to nearest-neighbor connections.

Building a RAM

A memory chip, such as a RAM, is a typical example of this kind of organization. We build a RAM compiler so we can generate a RAM with any word size and number of words. We are not restricted to a predefined word size or memory size.

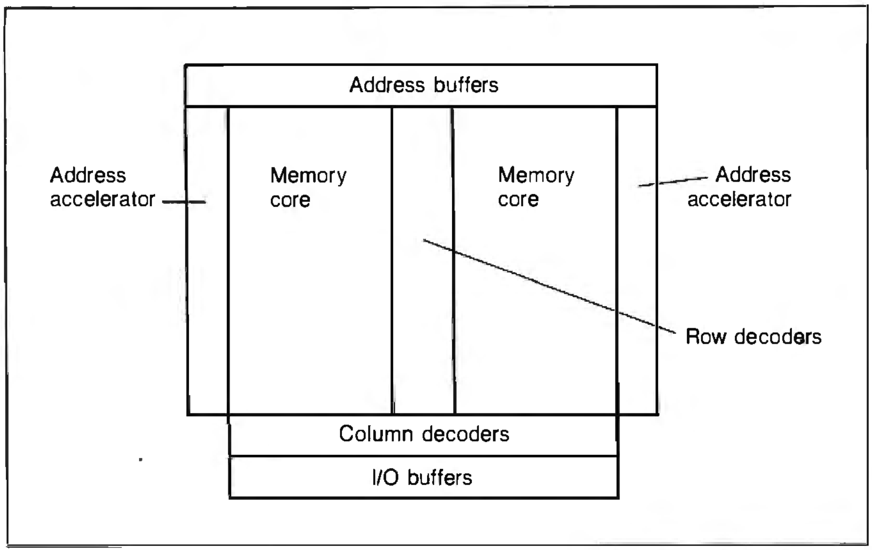

Figure 1: *A floorplan for a RAM chip.*

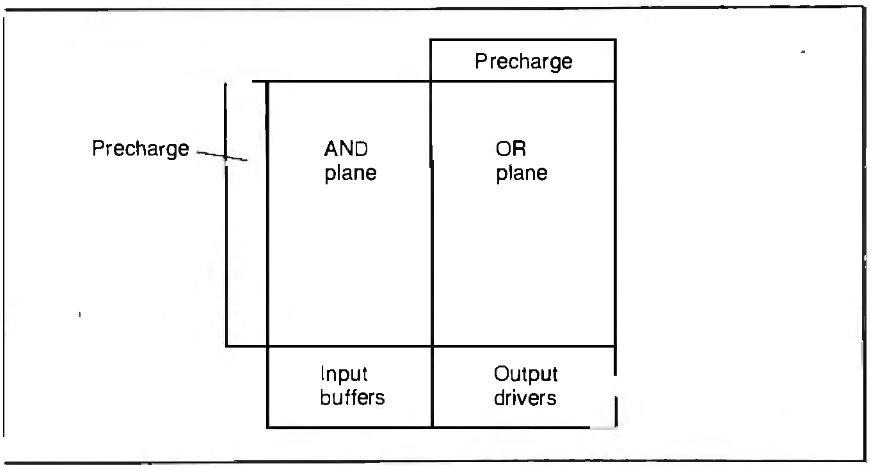

Figure 2: *The organization of a programmable logic array chip.*

Each regular array compiler has a fixed structure or "floorplan" it follows to build the layout (see figure 1). The RAM compiler builds the core array of the memory in two pieces, separated by address row decoders. The compiler puts address buffers on the top and address accelerators on the sides. On the bottom are the column address decoders, data line precharge circuits, sense amplifiers, and I/O buffers.

All cells in the core array connect to a horizontal address select line and a vertical data I/O line. The compiler does not make these connections explicitly because they are built into the memory cells. The compiler places the memory cells in the array, making the connections by abutment. Similarly, the peripheral circuitry connects to wires where they enter and leave the core array. The compiler adds sense amplifiers and additional decoders and finishes wiring the power and ground wires, sizing them to drive the entire memory circuitry.

RAM specification is very simple and requires only the word size and the number of words in the RAM. The compiler specification may include options to separate the read and write data lines, provide an output enable, or specify a faster access time. These specifications determine the size of the memory arrays, while their organization is prespecified in the floorplan.

All the cells in the compiler are predefined layout blocks. The compiler merely assembles the correct number of them in the correct order to produce the final assembly. The task is complicated by options that you may request. These options can often be satisfied by selecting a different kind of cell for the driver, based on the option desired. The compiler also calculates power consumption and sizes buffers and power wires to match the memory size. For example, a large memory with large word size requires large drivers for the decoders; a memory with more words of storage requires different sense amplifiers.

As a further complication, the core array of the compiler may not be completely regular. The compiler must take into account power and ground distribution and insert extra power supply connections in the core array at regular intervals as they are needed.

Other Regular Array Compilers

A RAM compiler requires only the number of words and number of bits per word

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There are virtually as many ways to specify datapaths as there are compiler products available.

to be specified because each bit of the RAM is identical. Other memory compilers require more specification. A ROM compiler, for example, also needs the data to be programmed into each memory location. A slight modification of a ROM is the programmable logic array, where each cell represents an input to a NAND or NOR gate for implementing control logic. The PLA is similar to the ROM in that each input to the NAND or NOR gates must be specified.

You implement the programming by defining two cells with identical size—one for an on bit, one for an off bit. You take programming data from a file to select which cell goes into each location in the core array.

Each memory compiler has a different structure. The RAM has two memory arrays with address decoders and sense amplifiers. The PLA shown in figure 2 has two arrays, one for computing AND terms and one for OR terms. The PLA has input buffers and output drivers as well as precharge circuitry around the core arrays.

There are many other types of memory compilers including first-in/first-out (queue), last-in/first-out, (stack), and multiport RAM compilers. These compilers share the common characteristic of generating uniform arrays of identical cells surrounded with support circuitry. The dissimilarities include different kinds of cells and a different number and arrangement of arrays.

Memory compilers are not the only regular array compilers. Systolic array processor compilers build a regular array of processors. Each processor computes a partial solution to a problem as the data flows through the array of pipelined processors. Systolic array processors have been designed to compute array multiplication, solve linear equations, and perform image-processing tasks.

Partially Regular Array Compilers

Partially regular array compilers are a generalization of simple array compilers. The layout here is still a two-dimensional array of simple functions. In one direction, the same function is repeated with local and global communication. In the other direction, different functions are placed. The layouts of these functions must follow conventions to allow them to tile together easily. The wiring between dissimilar functions is much less structured than in the regular array compiler. You can think of the partially regular array compiler as building a custom cell—sometimes called a bit slice—and then repeating the bit slice.

A typical partially regular array compiler is a datapath compiler. A datapath compiler is optimized for multibit logic and arithmetic. Every microprocessor has some multibit logic in it in the form of an ALU, adders, and registers. A very popular off-the-shelf part is the bit-slice datapath multiplexer, such as the 2901 from Advanced Micro Devices. With TTL designs, the 74181 ALU and other 4-bit packages are often used to build multibit logic. A datapath compiler provides a general mechanism for constructing your very own customized 2901-type design.

The datapath compiler is similar to a simple array compiler in that it builds repetitive structures in at least one direction: The same logic is simply applied to multiple bits. However, the specification of a datapath is much more complex, requiring a schematic or equivalent. You must describe the functions you want in the basic bit slice and how they should be wired. The compiler may optimize placement of the functions to minimize wire length and wiring congestion, making a faster, smaller chip. The compiler may also check that the datapath elements are connected reasonably.

There are as many ways to specify datapaths as there are products available. Some datapaths use textual languages that select the functions and describe their interconnection. Other systems provide an interactive way to fill out forms that describe the datapath. Still others provide a way to draw a schematic as a specification. In all cases, the result is the same: A bit-slice block is constructed of dissimilar elements, and then that bit slice is repeated.

A Sample Datapath

To illustrate how a datapath compiler works, let's examine a very simple 8-bit accumulator. The accumulator consists of an ALU with a register on each input. One of the registers can be either preset or can get the result of the ALU operation. The schematic for this datapath is shown in figure 3.

Each block in the schematic represents an entire functional unit, which could range from the simple two-input multiplexer up to a register file or barrel

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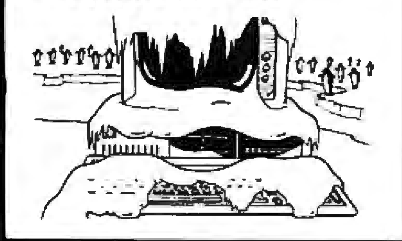

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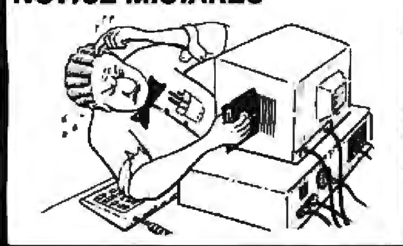

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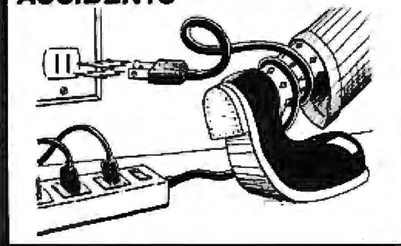

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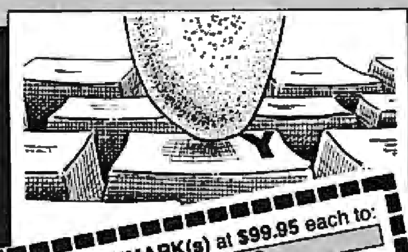

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shifter. The wires in the schematic represent entire buses. No control signals (such as the operation control for the ALU) are necessary in this specification, since the blocks imply the existence of the control signals.

The process of compiling this specification schematic into an optimized layout starts by creating a bit-slice block to implement the function. This bit-slice block will need to include four cells: two registers, a multiplexer, and an ALU. The compiler automatically orders these cells to minimize the wiring between them and also automatically routes them. Once the bit slice is created, it is repeated. Figure 4 shows an overall floorplan for the resulting layout.

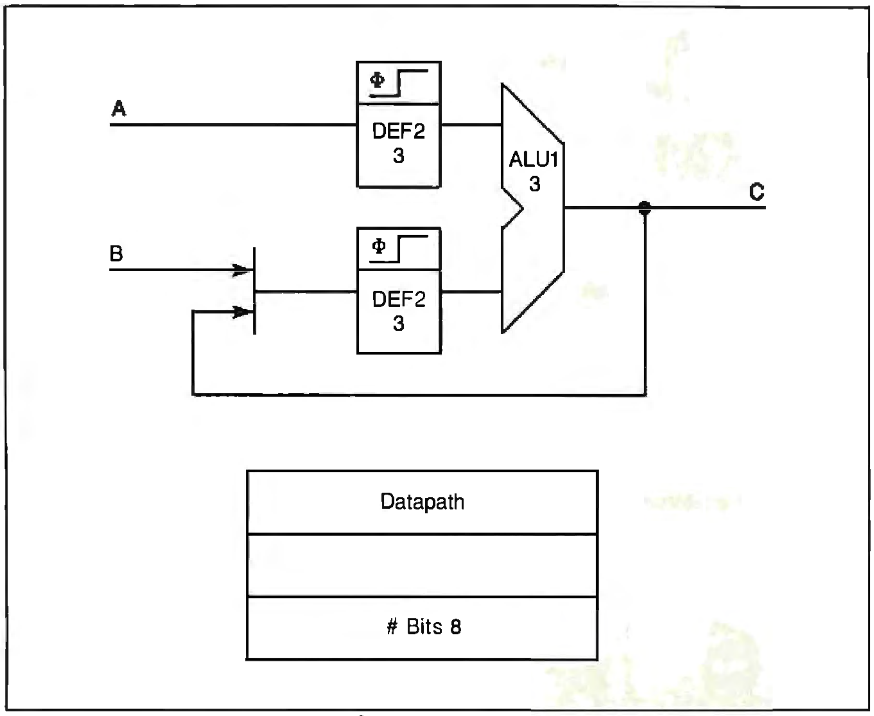

Figure 3: *The datapath logic specification for an 8-bit accumulator.*

The wiring within the bit-slice block between different cells is unique for each datapath. Between bit slices the wiring is very similar to that used in the RAM and other regular array compilers. The layouts of the individual cells have built-in connections to their nearest neighbors that are connected by abutment when the bit slices are arrayed. Along the top of the array of bit slices are placed control signal buffers to interface between the control logic and the insides of the datapath.

A CPU execution unit is obviously a datapath, but a datapath processes any multiple-bit data, so it is a very general mechanism that can be used to design any piece of multibit logic. Some examples of datapath applications include pipelined functions, counter/comparator logic, register/shifter logic, and cache memory handlers. These datapaths can contain dozens or hundreds of cells.

The above description concentrated on the layout generated by the compiler. Today's compilers can also generate a gate-level network connections list (netlist) for their functions. These netlists are suitable for input to gate array and standard cell implementations. Gate arrays provide for

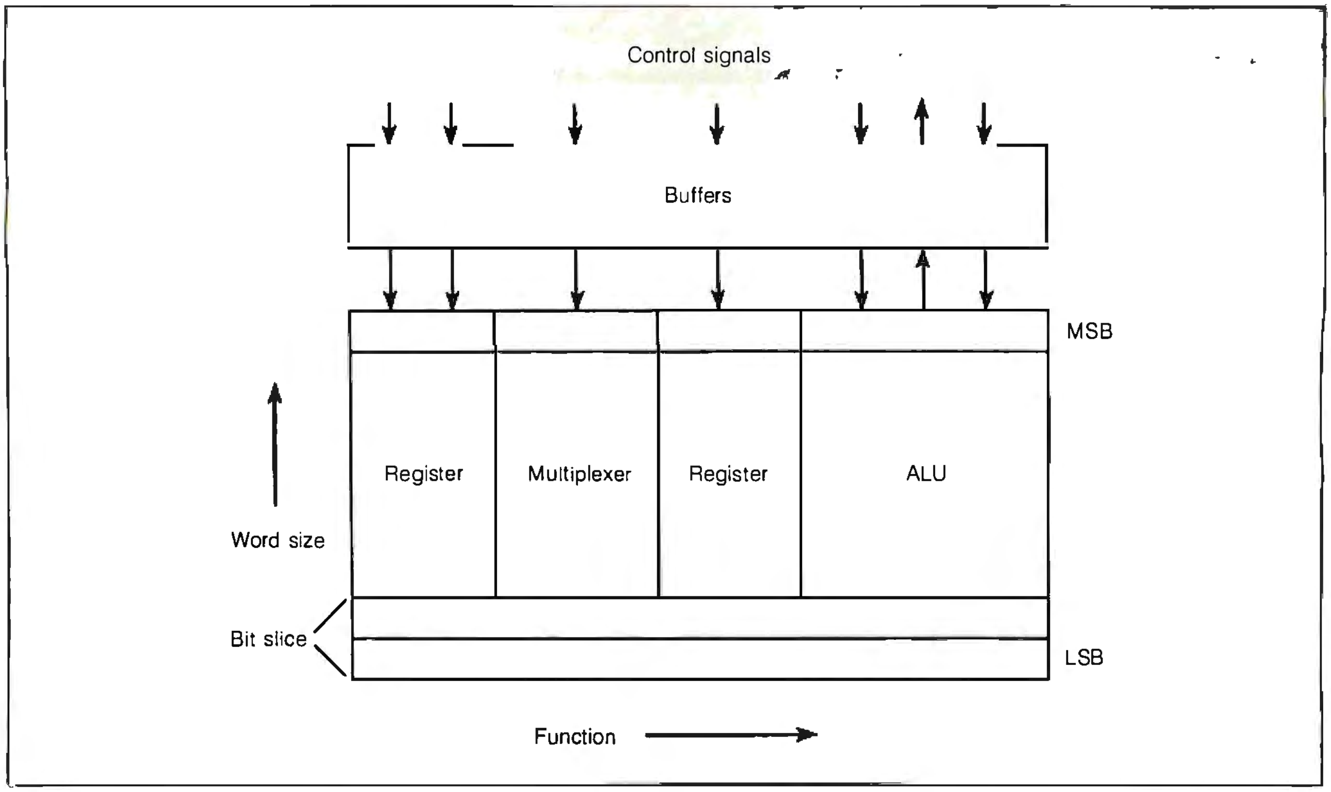

Figure 4: *The floorplan used by a silicon compiler for a datapath component.*

A logic compiler can implement any function that is expressed in equations, whereas more regular compilers are limited.

quick turnaround implementation and small quantities. Standard cells are quite flexible when floorplanning a complex chip with other large blocks, such as memories. Both gate array chips and standard cells provide a convenient way for people to add their own functions within the overall datapath environment without doing any custom layout.

Nonregular Compilers

Many functions that we wish to implement on an IC do not fit into regular structures of any kind. These functions are usually control functions or glue logic between large blocks or systems. They do not fit into a regular structure, so we have a class of silicon compilers that let users specify functions as equations and implement those functions as collections of gates wired together (see figure 5). A compiler of this type is called a *random logic* or *state machine* compiler, depending on the features of the input language.

Control logic is difficult for most silicon compilers because there is no regular, repetitive structure to exploit. Unlike memories and datapaths, each piece of control logic is unique, requiring a unique layout.

A state machine offers a convenient way to express control logic. A state machine is always in a specific state. The current state and the inputs determine the next state and the values of the outputs. A user can define Boolean equations of significant complexity to express the conditions under which the machine changes states and the values of its outputs. A set of random logic equations is a special case of a state machine with no states.

The state machine is a very good model for control logic for sequencing, peripheral control, or microcode. The specification of the equations may be very complex, including multiple-bit values, comparisons, and conditionals. The example shown in figure 6 is a state machine description of a traffic-light controller. The default state of the lights has the highway light (hl) green and the farm road light (fl) red. When a car trips

continued

the sensor on the farm road, the lights change to let the car go through the intersection. There is one state in the state machine for each state of the lights.

The silicon compiler has a target collection of gates. The gates are Boolean logic gates—such as AND, OR, and NAND—plus some registers, latches, and complex gates. In the first step, the compiler translates the input equations into a netlist, a collection of these gates and their interconnections. In the second step, the compiler uses a general placement and routing package to implement the layout.

Let OUT = A & B | C & B

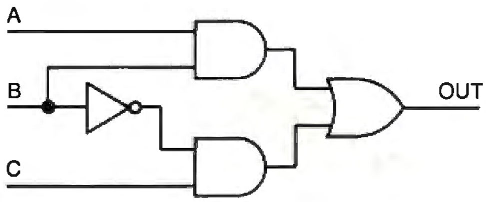

Figure 5: *A Boolean equation and the logic gates a silicon compiler generates for it.*

```
sm Traffic; # Traffic-light controller

define color        red green=0 yellow=1;

clock clk 65;
reset !reset —> hg;

latched inputs car;
inputs tlong tshort;
latched outputs st;
outputs hl:color=red fl:color=red;

state hg car & tlong  —>  hy  st  hl=green,
                      —>          hl=green;    # state defaults to same
state hy tshort       —>  fg  st  hl=yellow,
                      —>          hl=yellow;   # single-bit outputs
state fg !car | tlong —>  fy  st  fl=green,    # default to off, unless
                      —>          fl=green;    # the designer says to
state fy tshort       —>  hg  st  fl=yellow,   # default to something
                      —>          fl=yellow;   # else.
end
# the first guard satisfied is taken and blank is true, so in state HG you
# stay in HG when !(car & tlong)
```

Figure 6: *The state machine description of a traffic-light controller.*

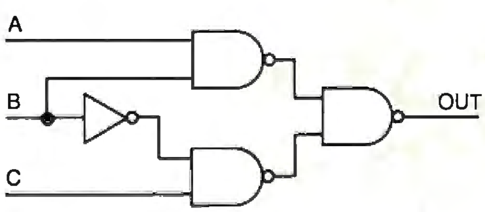

Figure 7: *The optimized logic diagram for the circuit described in figure 5.*

Logic optimization for large collections of logic is still an unsolved problem. A current solution reduces the equations to two-level logic and optimizes each output independently. It then searches the entire system of Boolean equations, extracting common factors. Finally, the compiler substitutes smaller gates for larger gates where possible, such as substituting NAND-NAND for AND-OR logic, as seen in the optimized version of our simple example (see figure 7). The result is an implementation of the logic that is usually better than a designer would make. It is more consistent, faster, and less error-prone.

The final placement and routing of the netlist can go to a gate array or a standard cell system. A gate array is a two-dimensional array of identical cells that are personalized and interconnected with the logic from the netlist. A standard cell chip consists of rows of nonidentical cells with routing between the rows. Usually, both gate array and standard cell implementations are less efficient than arrayed datapaths and memories because the general interconnections consume space and reduce performance. There are no built-in, optimized communication paths like those in memories and datapaths. However, a logic compiler can implement any function that is expressed in equations, whereas more regular compilers are limited in their function.

Many silicon compiler systems implement control logic in PLAs to take advantage of their regularity. However, while PLAs are a simple regular structure to build, they often do not meet the performance or area constraints required in a design.

What's Next?

The design of silicon compilers is certainly an active area of research and development, one where we can expect to see radical changes. Some of the areas in which we expect to see rapid advancement include automatic test generation for compilers; higher-level, more focused specification languages; compilers that call other compilers to build very complicated systems; other silicon floorplans that give rise to whole new classifications of compilers; analog circuits; and process technologies other than silicon, such as GaAs. ■

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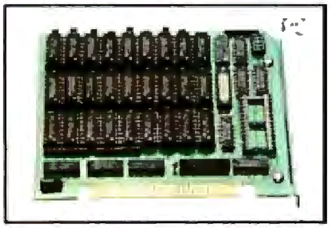

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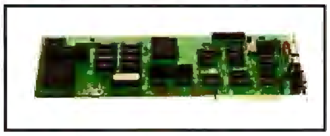

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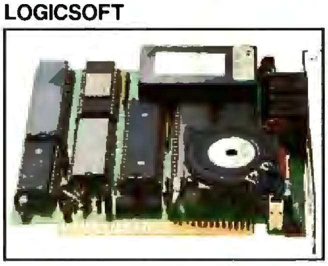

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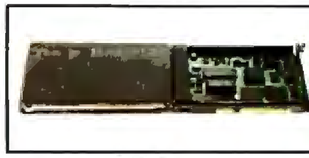

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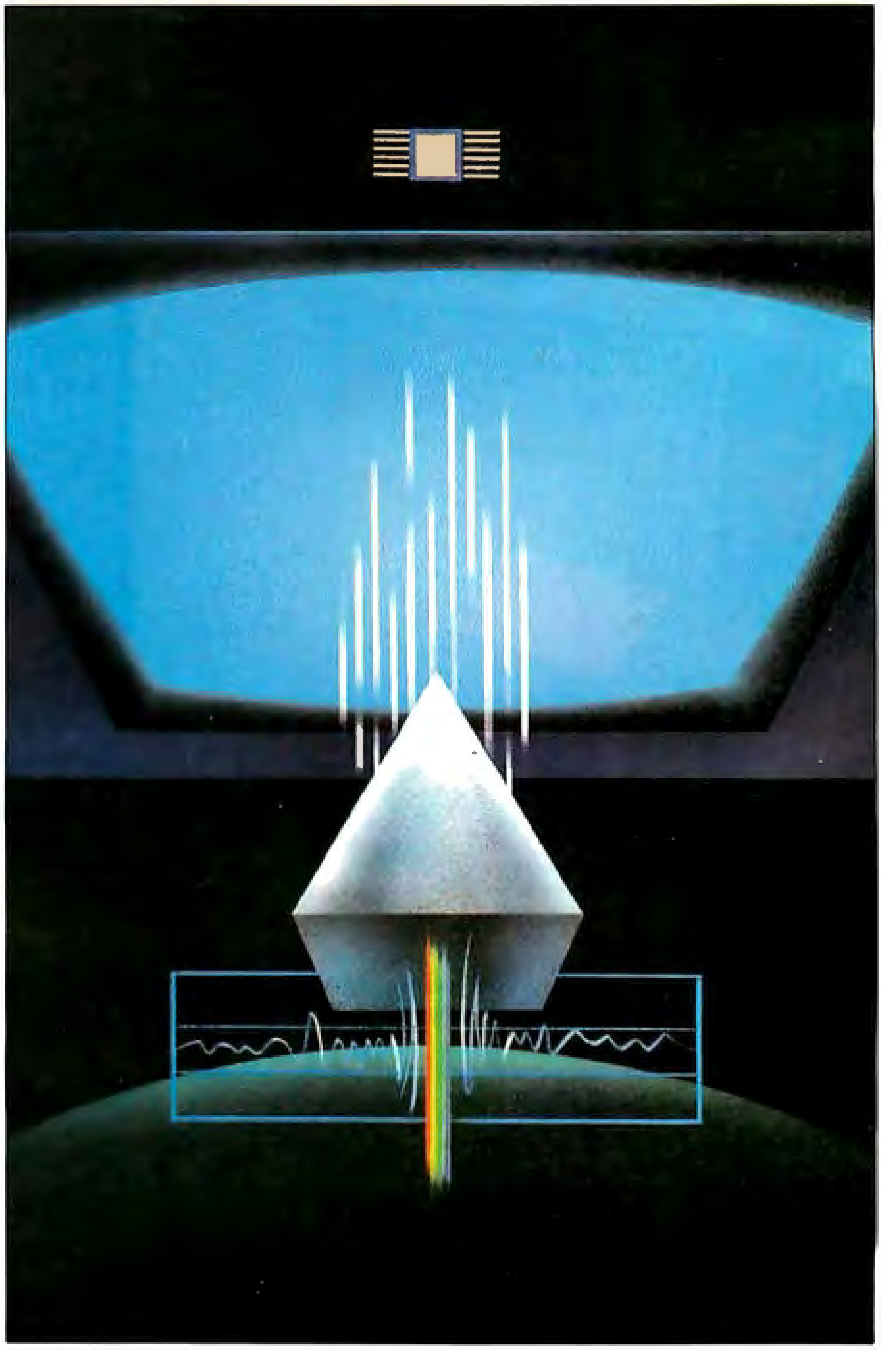
Reviews

Special BIX supplement: The following bonus reviews appear in the BIX conference jun87.sup: "The IBM PC XT Model 286" (by John Unger), a look at IBM's unusual hybrid of an XT chassis with an AT's CPU; and "Turbo Prolog versus Chalcedony Prolog" (by Robert Schalkoff), two very different, low-cost implementations of Prolog. (For information on joining BIX, see page 337.)



Turbo BASIC, Borland International's answer to Microsoft BASIC, has elicited yet another BASIC compiler from Microsoft: QuickBASIC 3.0. Like Turbo BASIC, the new version of QuickBASIC supports Intel's 8087 and 80287 math coprocessors. BYTE technical editor George A. Stewart, who wrote the Product Preview of Borland's Turbo BASIC compiler that appears in the March issue, reports below on a prerelease version of QuickBASIC 3.0. (For more details, see page 60.)

Beyond the magazine's pages, two additional reviews appear in the jun87.sup conference on BIX. Robert J. Schalkoff examines two implementations of Prolog: Chalcedony Prolog 1.10 and Borland's Turbo Prolog 1.1. The two implementations are quite different: Unlike Turbo Prolog, a typed compiler, Chalcedony Prolog is an untyped interpreter. Robert recommends Turbo Prolog for beginners because of its friendly, structured environment, many program examples, and compiling capability. Chalcedony Prolog is better if you're looking for full Clocksin and Mellish compatibility. (Contact Borland International, 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438-8400, and Chalcedony Software, 5580 La Jolla Blvd., Suite 126, La Jolla, CA 92037, (619) 483-8513.)

In the second BIX review this month, John Unger looks at IBM's PC XT Model 286, a hybrid that's a cross between the IBM PC XT and PC AT. Although IBM recently dropped the price of the Model 286 from \$3995 to \$2810, John still considers this a premium price to pay for a PC XT-compatible computer.

—Cathryn Baskin
Senior Technical Editor, Reviews

Microsoft's QuickBASIC 3.0 compiler includes support for the 8087/80287 floating-point processors, allowing math-intensive applications in BASIC to run up to 30 times faster than they can on systems lacking the Intel chip.

To test QuickBASIC's new math capabilities, I ran the Savage benchmark (see *Dr. Dobb's Journal*, September 1983, pages 120 to 122) using Microsoft BASIC 2.0 and 3.0 and Borland's Turbo BASIC 1.0. The host computer was a 4.77-MHz IBM PC equipped with an 8087.

QuickBASIC 3.0 took 6.4 seconds to run the test and had an error of 8.7×10^{-11}. Turbo BASIC 1.0 ran the test in 4.7 seconds with an error of 5.0×10^{-12}. Table 1 summarizes the results of these and additional tests.

Table 1: *Savage floating-point benchmark results.*

Run-time program	Time	Double-precision result	Error
QuickBASIC 2.0	175.5	2499.999999941009	5.899×10^{-8}
QuickBASIC 3.0 with 8087	6.4	2500.000000000087	8.7×10^{-11}
QuickBASIC 3.0 emulating 8087	240.7	2500.00000000024	2.4×10^{-10}
QuickBASIC 3.0 binary-format math pack	175.5	2499.999999941009	5.899×10^{-8}
Turbo BASIC 1.0 with 8087	4.7	2500.000000000005	5.0×10^{-12}
Turbo BASIC 1.0 emulating 8087	139.7	2500.000000000005	5.0×10^{-12}

Numeric coprocessor support is great for users whose computers have the coprocessor chips but a mixed blessing for those who do not. One standard solution, available in QuickBASIC and Turbo BASIC, is for the compiler to emulate the coprocessor in software. This approach preserves software compatibility but at a great cost in speed. For instance, using 8087 emulation, QuickBASIC 3.0 took 240.7 seconds to run the Savage benchmark with an error of 2.4×10^{-10}. Notice that QuickBASIC's emulation accuracy is different from its 8087 result: Programmers must use caution in writing software that must run the same way in both coprocessor and emulator environments.

For users who don't have 80x87s and don't want to run the slower emulation routines, QuickBASIC 3.0 comes with a noncoprocessor version; the math module is the same one that is used in QuickBASIC 2.0 and BASICA and is based on Microsoft's own binary-format system.

What about compatibility between the two versions? The most obvious problem here concerns random-access data files containing numbers in Microsoft's binary format; these values must be converted to the 80x87's IEEE format before they can be used in a coprocessor environment.

QuickBASIC 3.0 offers a couple of solutions. One is a `/MBF` configuration switch used when you start the program; it tells the compiler that all numbers in random-access disk files must be converted into the IEEE format as they are read into memory and vice versa as they are written back out to random-access disk files. The other solution is to use a set of the new built-in conversion functions for going back and forth between the two numeric formats.

Another more subtle compatibility issue regards how programs will operate under the IEEE and Microsoft binary-format systems. The IEEE numbers allow for a much wider dynamic range and from one to two digits of added precision. These differences could affect the operation of certain programs that compare values for equality or that generate very large intermediate results. We'll continue to deal with these issues in future reviews of BASIC compilers.

Numeric coprocessor support isn't the only new feature of QuickBASIC 3.0. Perhaps most important for program developers are the improvements to the debugging environment. These include program breakpoints; watch variables, which give you a dynamic view of selected variables' contents; and the generation of descriptive compiler error messages during batch (command-line) compilation.

—George A. Stewart
Technical Editor

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Beyond Turbo

Wayne Rash Jr.

*PC's Limited's 286^{12} and Wells American's A*Star II, two 12-MHz machines*

The quest for speed continues. With each passing month, the speeds of Intel 80286-based computers creep inexorably higher. Two of the latest speed demons are PC's Limited's 286^{12} and Wells American's A*Star II. These fast machines are relatively low-cost clones of the IBM PC AT. The 286^{12} has a list price of $1999 for the basic model, and the A*Star II basic model costs $2295. They are both much faster than the PC AT and boast some unique capabilities.

The 286^{12} is distinguished by having a front panel of sorts. This feature has all but disappeared from personal computers; 10 years ago, nearly every machine had one. The front panel is a small alphanumeric display that tells what the computer is doing. When you boot the 286^{12}, it lists the boot-up ROM programs that are running. After boot-up, the display shows the microprocessor speed when it is changed, the letter of the disk drive being used, and the number of the track that's being accessed.

The A*Star II that I reviewed came configured for network use (see the text box "Using the A*Star II LAN" on page 000), and it signs on calling itself a multiuser computer. It also came with the Wells American Multiuser Network Operating System. This computer is obviously aimed at the business market; its version of GW-BASIC is labeled "Business BASIC." Unlike the 286^{12}, which is switchable only between 6 MHz and 12 MHz, the A*Star II gives you a wealth of speed choices. It is switchable among 6, 8, 10, and 12 MHz, and you can choose between no wait states and one wait state in the 6- and 8-MHz speeds. This enables you to operate add-on boards at their highest possible speeds, even if they won't go as fast as 12 MHz.

The great speed of these computers is likely to cause problems with add-on boards, especially memory boards. [Editor's note: *For more information on this problem, see "Nine PC AT Multifunction Cards" by Wayne Rash Jr. in the January BYTE.*] There was a time when some software companies had copy-protection schemes that depended on a 6-MHz microprocessor on a PC AT to work, but this practice has mostly been abandoned. I have not found any software that has problems running at 12 MHz, although some games run too fast to be played.

The 286^{12}

The 286^{12} allows you to switch microprocessor speeds at any time. This switching can take place within a program, which means that if you have software that needs 6-MHz speeds to satisfy its operation or copy protection, you can still run at 12 MHz the rest of the time.

You switch between speeds by simply typing the Ctrl-Alt-\ (backslash) key sequence. When you shift to 6 MHz, you are greeted by a single beep from the speaker, and the front panel says "6 Mz." A shift to 12 MHz results in a two-tone beep and a "12 Mz" reading from the front panel. While writing this paragraph, I was able to switch speeds from within WordStar without problems.

The front-panel display is called SmartVu, and it is a handy device. Besides telling you how fast the machine is running, the SmartVu readout can display error messages and diagnostic indicators. When you perform a cold boot, the display indicates which ROM diagnostic routines are being run. When the memory is tested, you get a display of the RAM address that is under test. When the time comes to boot the system, the word `boot` appears on the display, followed by the drive and track that the disk controller is telling the drives to read.

All this activity is reassuring, but there's more to it than that. If the machine fails to boot, you can see where in the process the failure happened. If a program hangs, you will see that the disk drives are no longer accessing tracks, despite the drive light being on. Next to the SmartVu readout are two LEDs: a green

continued

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (1777 North Kent St., Arlington, VA 22209), where he consults with the federal government on microcomputers.

	PC's Limited 286^{12}	Wells American A*Star II
Company:	PC's Limited 1611 Headway Circle, Bldg. 3 Austin, TX 78754 (512) 339-6800	Wells American 3243 Sunset Blvd. West Columbia, SC 29169 (803) 796-7800
Size:	21 by 16½ by 6½ inches; 43 pounds	21¼ by 17¼ by 6½ inches; 37 pounds
Components:	Processor: Intel 80286, switchable between 6 MHz and 12 MHz with one wait state Memory: 1 megabyte, expandable to 16 megabytes Mass storage: One half-height 5¼-inch 1.2-megabyte floppy disk drive or one 360K-byte floppy disk drive and one 40-megabyte hard disk drive Display: 12-inch monochrome, EGA, or CGA; 80 characters by 25 lines Keyboard: 84 keys; 10 function keys; indicator lights for Caps Lock, Scroll Lock, and Num Lock keys I/O interfaces: Eight slots: two IBM PC-compatible, six PC AT-compatible; two parallel ports on monochrome system; one parallel port on EGA system; two serial ports; one game port	Processor: Intel 80286, switchable among 6, 8, 10, and 12 MHz (optional) with one wait state; also switchable between no wait states and one wait state for 6 and 8 MHz Memory: 1 megabyte, expandable to 16 megabytes Mass storage: One half-height 1.2-megabyte 5¼-inch floppy disk drive or one 360K-byte floppy disk drive and one 30-megabyte hard disk drive Display: 12-inch monochrome; 80 characters by 25 lines Keyboard: PC AT-style: 84 keys; 10 function keys; indicator lights for Caps Lock, Scroll Lock, and Num Lock keys; RT PC-style: 101 keys; 12 function keys; indicator lights for Caps Lock, Scroll Lock, and Num Lock keys I/O interfaces: Eight slots; two IBM PC-compatible, six PC AT-compatible; two serial ports; one parallel port; one game port
Options:	I/O adapter card: $99 EGA video card: $299 CGA/EGA color monitor: $529 360K-byte floppy disk drive: $109 40-megabyte hard disk drive: $849	PC-DOS 3.1: $85 360K-byte floppy disk drive: $130 30-megabyte hard disk drive: $855 Monochrome monitor: $105 Video display card and parallel port: $95 I/O adapter card: $85 12-MHz capability: $395 Multiuser Network Operating System: $395 A*Star II Network adapter card: $395 A*Star II Network adapter/amplifier card (required for a workstation net with more than 32 stations): $495
Documentation:	User's manual, 102 pages	User's manual, 23 pages
Price:	Basic system: $1999 With 40-megabyte hard disk drive, 1.2-megabyte 5¼-inch floppy disk drive, and EGA color monitor: $3499	Basic Model 300 with 30-megabyte hard disk drive, I/O adapter card, and 1 megabyte of RAM: $2295 Basic Model 300 with A*Star II Network adapter card, monochrome graphics adapter, and monochrome monitor: $2890

one, which lights when the computer is running at 12 MHz, and a red one, which lights when the hard disk is in use.

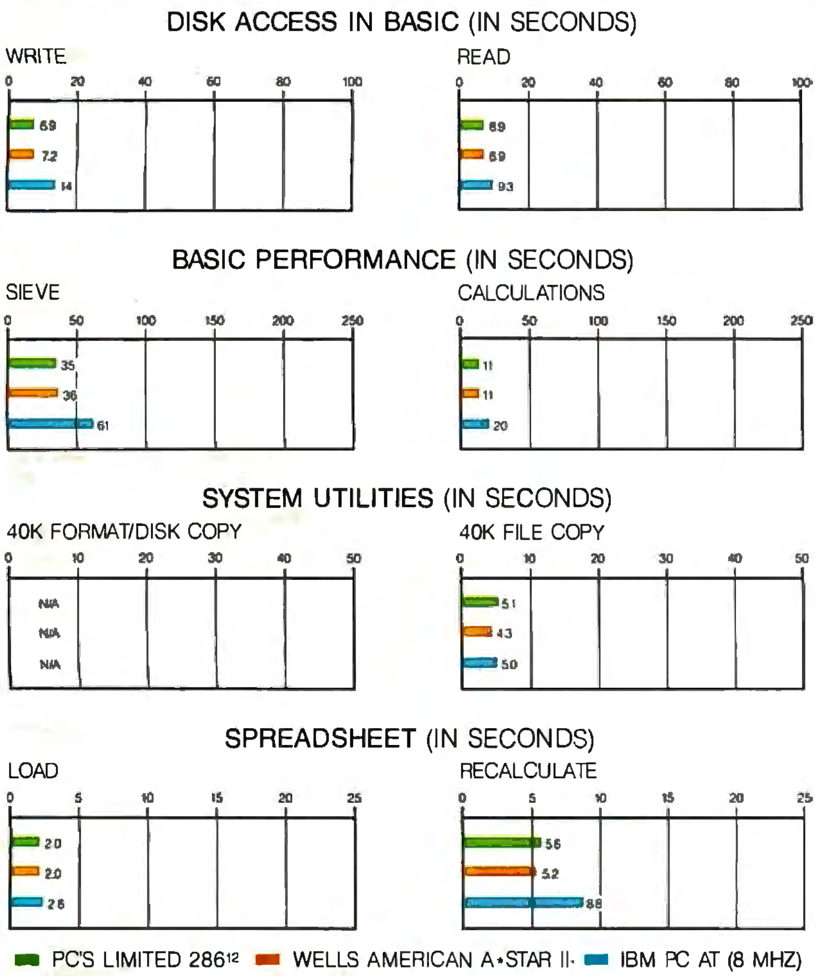
The more I used SmartVu, the better I liked it. Some applications require long periods of disk use, and it's comforting to see that the disk and the computer are both really working.

Inside the 286^{12}

The 286^{12} has a traditional IBM-style interior layout. It has eight expansion slots, six of which are 16-bit slots. The machine that I reviewed came with the maximum of 1 megabyte of memory on the motherboard. The 256K-byte, 100-nanosecond memory chips are soldered in place, so you'll need to have PC's Limited repair your machine if a RAM chip fails.

Located near the left edge of the motherboard is a DIP switch used for configuring the system. It is very much like similar switches on other PC AT clones, but, in a nice touch, PC's Limited has printed the switch functions next to the switch. This means that you don't have to dig out the manual every time you want to change display cards, for example.

The 40-megabyte Micropolis hard disk drive is located in the center of the computer. To the right is the bay for the 1.2-megabyte floppy disk drive, and enough room is left over for two other half-height disk drives, tape drives, or additional



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a 30- or 40-megabyte hard disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The 40K Format/Disk Copy benchmark was not performed because the computers had only one floppy disk drive. The 40K File Copy graph shows how long it takes to copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 100-row by 25-column spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft Multiplan 1.06. Tests on the 286¹² were done using MS-DOS 3.1 and GW-BASIC 3.1. Tests on the A*Star II were done using PC-DOS 3.1 and GW-BASIC 3.1. PC-DOS 3.2 and BASICA 3.2 were used for the 8-MHz IBM PC AT.

mass storage devices.

The 286¹² uses a 192-watt power supply, which should be adequate for any internal add-on equipment. The fan that cools this supply is louder than most, but it is not loud enough to cause distraction.

Using the 286¹²

The 286¹² that I reviewed had an optional I/O adapter card with two serial ports, one parallel port, and one game port. Also included was PC's Limited's optional EGA video card and CGA/EGA color monitor. The monitor is manufactured by Mitsubishi and produces text and graphics that are crisp and easy to read.

The keyboard has the same layout as the original PC AT design. The 10 function keys are on the left side in two vertical columns of five, and the Ctrl key is in its traditional location next to the *A* key. The keyboard has a crisp touch with distinct but unobtrusive audible and tactile feedback.

The 286¹² has an extensive set of user-selectable routines available in ROM. You can access these by simply pressing the Ctrl-Alt-Return key sequence. This causes a menu to appear on the screen.

The machine's ROM menu allows you to run the Setup program, park the hard disk heads, and find out the meaning of the error codes on the SmartVu readout. You can also set up some special operating conditions, such as not requiring a monitor or keyboard, or you can disable parity checking for RAM. All these capabilities are useful if you need to diagnose a problem.

When you change the configuration of the 286¹² (by adding more memory, for example), you get the same warning as you do on other PC AT clones; that is, you are alerted to the fact that the amount of memory actually in the machine and the amount of memory that the machine "thinks" it's supposed to have are different. Also, as with most other machines, you're asked to press F1 to continue. At this point, most other PC AT clones require you to go through the setup menus and figure out how much memory you need to add. The 286¹² also has a menu. But once you choose to make the memory adjustment, the computer takes care of the rest for you. The adjustment is made automatically, saved to the battery-backed CMOS RAM where configuration information is stored, and you are returned to MS-DOS. This is a procedure that other companies should consider for their machines.

Getting Started

Other than instructions for entering information about the configuration into memory, there's little in the user's manual about getting started with the machine. The 286¹² does not come with MS-DOS. In addition to the Setup program that is supplied on a disk for configuring the computer, you'll need a version of DOS and its manual to format and use the hard disk. I substituted Zenith's MS-DOS version 3.1, and it worked fine.

The A*Star II

Like the 286¹², the Wells American A*Star II is a fast, capable machine. While it lacks the flash of the front-panel display, it boasts the widest selection of microprocessor speeds of any machine I've used. The A*Star II comes with 6-, 8-, and 10-MHz speeds as standard equipment. The 12-MHz speed capability is a $395 option.

Changing speeds on the A*Star II is not as convenient as it is on the 286¹². For the A*Star II, you have to run a program called Speed. You enter SPEED and a nu-

continued

meric value for the proper speed (e.g., SPEED/12) at the system prompt. This returns a multiple tone that sounds a lot like something from a video game. You can do this from within a program, such as WordStar, only if the program will allow you to execute another program from within it. While this is a little more involved than the procedure for the 286[12], it's still practical. With many machines, you can change their speeds only with a switch, and you must reboot immediately thereafter.

Inside the A*Star II

At first glance, the interior of the A*Star II is very much like that of the 286[12]. The motherboard has eight expansion slots, six of which have 16-bit connectors. The machine that I reviewed came with an optional adapter card with two serial ports, one parallel port, and one game port. The 30-megabyte Seagate ST4038 hard disk is mounted in the center, flanked on the right by the 1.2-megabyte 5¼-inch floppy disk drive. There is room for two more half-height floppy disk drives, tape backup units, or hard disk drives. The power supply can handle a hefty 220 watts, which should satisfy nearly any requirement.

Despite the similarities between these two machines' interiors, there are also some important differences. The A*Star II's RAM chips are 256K-byte, 120-ns SIPs (single in-line packages). They are mounted on edge to conserve space. The first 512K bytes of RAM is soldered in place on the motherboard, and the remaining 512K bytes of memory is socketed, allowing easy removal and replacement.

A feature that will be appreciated by all-night hackers is that the batteries that power the A*Star II's CMOS RAM are four standard alkaline AA penlight cells. A box of these cells is included with the computer, and you can easily get replacements. This will save trouble for all users in the long run, because ordering batteries from the factory will no longer be necessary, and users won't have to call in a service representative to replace batteries.

On the rear of the machine is a system reset switch. This is an important addition that most clone companies are leaving off of their machines. With a reset switch, you have a chance of recovering your information if your software crashes and the machine does not respond to the Ctrl-Alt-Del key sequence.

Using the A*Star II

The A*Star II that I reviewed came with the optional monochrome monitor made by Wells American. The optional video display card is a clone of the Hercules graphics card. The result is crisp, clear text and excellent graphics. The card is compatible enough with the Hercules card to run Lotus Freelance Plus without a hitch.

Two keyboards are available for the A*Star II, one of which is a copy of the original IBM PC AT keyboard, and the other is a faithful copy of the 101-key enhanced keyboard that is on the current PC AT. The 84-key keyboard that came with my review unit was defective, and it caused double characters to show up from time to time. A new keyboard solved the problem. The Wells American keyboards have more obvious tactile and audible feedback than the 286[12]'s, but they are not loud enough to be objectionable.

Like the 286[12], the A*Star II handles

Using the A*Star II LAN

Wells American bills its A*Star II as a multiuser business machine. One of the reasons for this label is the local-area network that the company produces for use with the A*Star II. Wells American included an A*Star II Network adapter card and a coaxial cable with the unit I used for this review. I tried it out using the A*Star II as the file server and the PC's Limited 286[12] as a workstation. I also attempted to add a Zenith Z-148 to the network as a second workstation.

The Wells American Multiuser Network Operating System is a baseband LAN with a data transfer rate of 1.25 megabits per second. This is slightly faster than the 1-megabit-per-second Corvus Omninet and about one-eighth the speed of the 10-megabit-per-second 3Com version of Ethernet. It is not Netbios-compatible.

Of course, the actual speed at which data will transfer depends on many factors besides the raw capabilities of the hardware. Factors that slow a network down include the number of users, the capabilities of the network software, and the level of traffic on the network. As a result, most 10-megabit-per-second networks rarely transfer information faster than half their potential speed.

The Wells American LAN will support 256 independent users with a maximum of 254 workstations, and it will support up to 250 megabytes of disk space. It costs only $395 per workstation. Of course, you have to add the cost of an A*Star II computer, since the network requires that the A*Star II be dedicated as a file server.

Setting Up

The preliminary manual states that the network is designed so that any user can set the network up and use it. The interface boards are, according to Wells American, easy to install. Given the proper instructions, they may well be. Unfortunately, I tried to use this network with the preliminary documentation. Pictures, drawings, and examples would have been welcome. Because of this, my installation of the network was not entirely successful.

I did get the network to run, however. I was able to set up the A*Star II as the file server, and the PC's Limited 286[12] functioned as the workstation. I was able to move files to the server and run programs from there. I was not able to get the Zenith Z-148 to function as a workstation, however. It refused to recognize the existence of the network. I don't know if this was due to a compatibility problem with the Z-148 or with the LAN. [Editor's Note: *Wells American says it has not heard of any compatibility problems with its LAN during installation on other brands of computers*

I was able to set up a variety of disk partitions on the A*Star II, ranging from disk G: to disk K:. The disk F: partition, which was supposed to be available, refused to format. The network is designed to give each user access to as many as four public areas of the server's disk, as well as an additional four private areas. Again, this may have been a problem with the documentation or my installation. [Editor's note: *Wells American said it did not know what caused the problem.*]

Is It Worthwhile?

Setting up a network is one area in which even an experienced user needs detailed instructions and plenty of examples. In addition, a new user needs easy access to technical support. The instructions in the preliminary manual are sketchy at best. Fortunately, the help from Wells American is good. Still, you should consider your personal skills in this area before you take on the task of becoming a network administrator.

changes in configuration with aplomb. While the procedure for the A*Star II is slightly different, you still must press the F1 key and proceed to the setup menu in ROM. As with the 286^{12}, the A*Star II takes care of making the changes in configuration; you need only give it permission to do so.

Getting Started

Included with my A*Star II was the system setup disk and a copy of IBM's PC-DOS 3.1. Wells American offers PC-DOS 3.1 as an option for $85. There is specific information in the hardware manual about getting the computer running, but without the PC-DOS manual, a novice user wouldn't have enough information to format and use the hard disk drive. My review machine also came with the optional Multiuser Network Operating System for Wells American's local-area network, as well as drivers for the monochrome graphics card.

Documentation and Service

Neither of these computers excels in the completeness of its documentation. Of the two, however, the 286^{12} has the superior user's manual. This is not to say that the A*Star II's manual is inadequate, but that it contains the minimum information necessary.

The A*Star II user's manual is only 23 pages long. It includes a number of drawings that clearly illustrate the procedures being covered, and basic operations are explained. Also included is a discussion of some of the initial steps necessary for setting up the system with PC-DOS.

The 286^{12} user's manual also contains all the information you need to set up and operate the system. In addition, it gives clear explanations of troubleshooting, adding accessories, and a description of operations supported by the ROM. Regrettably, it also contains some errors in its description of the SmartVu functions. A function called SmartVu Scan, a bar graph display that is available on other PC's Limited computers, such as the 286^{8} and the 286^{10}, was not available on my review machine.

Neither PC's Limited nor Wells American has a large national dealer network. In situations such as this, service is always a concern. Wells American has retained the RCA service organization to provide repairs of its equipment. RCA service is widespread, so service should be readily available. PC's Limited doesn't offer third-party service, but it does offer to help resolve problems over the phone when you call its toll-free number. When this will not work, you must ship the computer back to PC's Limited's service facilities. The company says that you need to call for a return authorization before shipping your computer.

The benchmark times for these machines were very similar—within a few tenths of a second of each other. I performed benchmarks on the hard disks only and used a larger spreadsheet developed for faster machines for the Spreadsheet benchmarks.

The times obtained for these tests echo the closeness of the times in the other tests. The results for the Sieve and Calculations benchmarks show these machines to be almost twice as fast as the 8-MHz IBM PC AT. For the complete benchmark results, see page 231.

The Final Verdict

I enjoyed working with both of these machines. Of the two, I preferred the PC's Limited 286^{12}, primarily because of the SmartVu readout and the ease of changing speeds. However, I was concerned with the limited service arrangements. Frankly, I would not refuse either machine if I had to work with one on a regular basis. These machines perform well, and they are quite fast. ■

Turbo-Amiga

Warren Block

A peripheral for the Amiga 1000 that's actually another computer

The Turbo-Amiga add-on package for the Amiga 1000 by Computer System Associates (CSA) consists of Motorola's 68020 processor, a 68881 math coprocessor, and 512K bytes of 32-bit-wide RAM for $3670. The Turbo-Amiga connects to the expansion slot of the Amiga 1000 and essentially takes over the machine when it runs. Housing for the processor and memory cards is provided by a five-slot Zorro-compatible expansion box, which is called the Turbo Chassis, with a 100-watt switching power supply and cooling fan. (Zorro is a bus standard designed by Commodore that expands the 86-pin expansion slot to a 100-pin backplane.) One slot on the Chassis is occupied by the 68020/68881 processor board, and another is taken up by the 512K-byte memory board, leaving three slots for other expansion options.

CSA also offers a 2-megabyte 32-bit-wide memory board, an SCSI (small computer system interface) hard disk controller, and 20-, 40-, or 80-megabyte hard disks to fit inside the Turbo Chassis. Also available is a removable portable Secure Data Cartridge (essentially a self-enclosed 20-, 40-, or 80-megabyte hard disk) for applications in which security or portability of data is necessary. [Editor's note: *CSA also offers a board with a 68020 processor and a 68881 coprocessor, as well as a 32-bit 512K-byte or 2-megabyte memory board for the Amiga 2000. The processor board fits into the 2000's processor slot, and the memory boards fit into the Amiga bus slot. These products will be available when Commodore begins shipping the Amiga 2000.*]

Hardware and Software

The Turbo-Amiga's 32-bit 68020 processor runs at 14.28 MHz, twice the speed of the Amiga's 32-/16-bit 68000. Another increase in speed is possible using the Turbo-Amiga's 32-bit-wide memory, allowing you to fetch a 32-bit memory value with one 68020 processor access rather than the two required for the 16-bit-wide Amiga 1000's RAM. The data-bus connection between the Amiga 1000 and the Turbo-Amiga is only 16 bits wide, so any transfer of data between the two devices will not benefit from the use of the Turbo-Amiga's memory. Additionally, graphic images must be located in the 16-bit-wide memory on the Amiga 1000 for the blitter chip to address them.

The Turbo Chassis is a 10- by 9-inch metal box that is the same beige color as the Amiga and has large rubber feet on the bottom. On the front are two LEDs: One is a power indicator, and the other shows when the internal hard disk is being accessed. The latter is unused when the hard disk option is not present (as was the case with the review unit I examined). Four vertical slots in the front of the box allow air circulation for the internal boards. The construction is rugged and somewhat utilitarian.

Included with the Turbo-Amiga is a 3½-inch floppy disk with programs for enabling and testing the Turbo-Amiga: ABasiC version 1.0 (Metacomco's BASIC interpreter that was originally packaged with the Amiga), BASIC programs for testing the Turbo-Amiga's memory and 68881 math coprocessor, and a public domain program that plots Mandelbrot graphics.

The documentation provided with the unit that I reviewed consisted of two binders with photocopied instruction sheets prominently marked "Preliminary." The sheets were copies of various articles describing the 68020 and 68881 chips; engineering drawings of the chassis, processor, and memory boards; and benchmark times and listings. The sections describing the installation and use of the Turbo-Amiga were terse, but, considering the ease with which you can install the hardware, they were sufficient. [Editor's note: *The documentation now provided with the Turbo-Amiga consists of two manuals:* 68020 Turbo User's Manual *and* 68020 Turbo User's Manual and Illustrated Parts List.]

Installation and Use

To connect the Turbo-Amiga, you remove the plastic cover to the Amiga 1000's expansion port and slide the Turbo-Amiga's connector into it. This makes the computer about 9 inches wider, which presents a problem if you own an external disk drive, as the Turbo-Amiga occupies the area where the drive normally rests. However, you can resolve this problem and save space by setting the external disk drive vertically on top of the Amiga 1000 between the monitor and the Turbo-Amiga.

The documentation warns that you should always apply power to the Turbo-Amiga first instead of to the Amiga 1000, lest you damage both machines. The simplest way to accomplish this is by plugging the Amiga 1000 and the monitor into the electrical outlets provided on the back of the Turbo Chassis.

My initial experiences with the Turbo-Amiga were frustrating: The system would usually, but not always, crash when I loaded another disk into the disk drive. The documentation warned that some Amigas might require a small hardware patch to work correctly with the new equipment due to inadequately grounded chips on the Amiga's Kickstart RAM daughterboard. Installing the patch voids the warranty on the Amiga, but, since mine had expired, I went ahead and installed it. The patch consisted of solder-

continued

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Turbo-Amiga

Type
Expansion chassis with a 68020 processor, a 68881 math coprocessor, and 512K bytes of RAM for the Commodore Amiga 1000

Company
Computer System Associates Inc.
7564 Trade St.
San Diego, CA 92121
(619) 566-3911

Size
10 by 9 by 8¾ inches; 11 pounds

Components
Processor: 14.28-MHz Motorola 68020 with 68881 math coprocessor
Memory: 512K bytes of 100-nanosecond, 32-bit-wide RAM
Chassis: Five-slot Zorro backplane with 100-watt switching power supply and fan

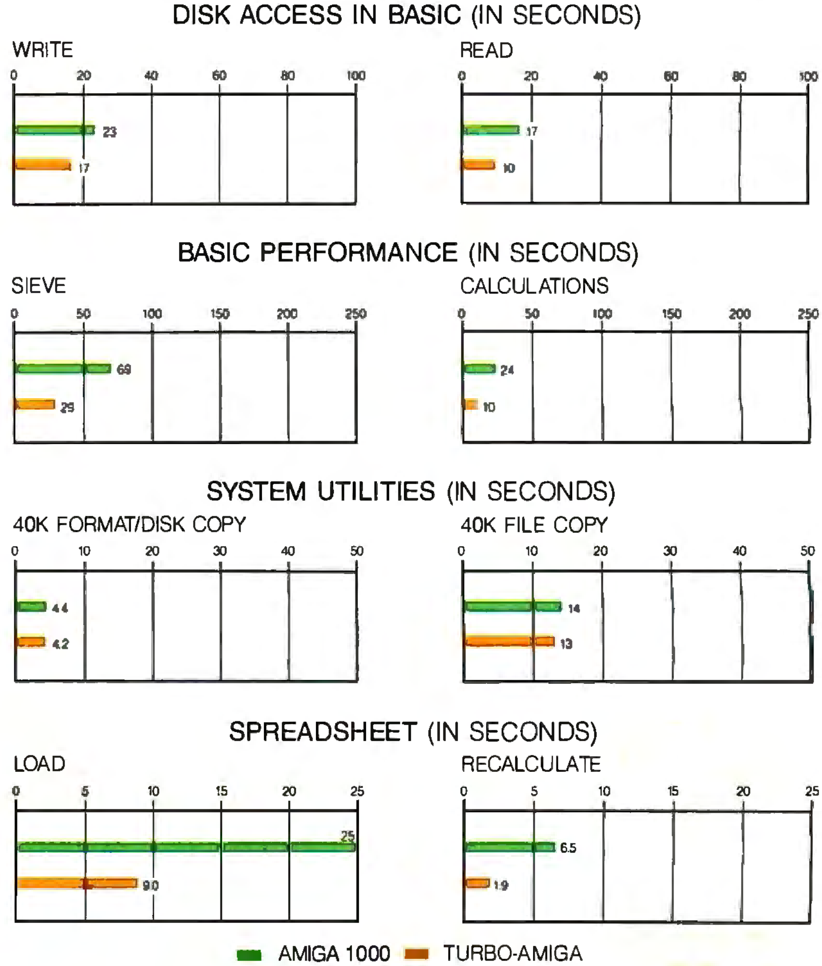
Software
One 3½-inch disk with ABasiC 1.0 and utility, test, and demonstration programs; not copy-protected

Options
2-megabyte 32-bit static memory board: $3995
SCSI hard disk controller: $745
20-megabyte hard disk: $945
40-megabyte hard disk: $2200
80-megabyte hard disk: $2300
20-megabyte Secure Data Cartridge: $895
40-megabyte Secure Data Cartridge: $3895
80-megabyte Secure Data Cartridge: $4090
Turbo Chassis for Secure Data Cartridge: $995

Amiga 2000 products:
68020/68881 processor board: $1480
512K-byte 32-bit static memory board: $1295
2-megabyte 32-bit static memory board: $3995

Documentation
68020 Turbo User's Manual
68020 Turbo User's Manual and Illustrated Parts List

Price
68020/68881 processor board: $1480
512K-byte 32-bit static memory board: $1295
Turbo Chassis: $895



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The Calculations benchmark had to be modified (the DEFSNG statement was removed) before it would run. Tests were run using Kickstart/Workbench 1.2. The spreadsheet used was Lattice's Unicalc 1.0; Metacomco's ABasiC 1.0 was used for all BASIC tests. Note: The System Utilities times originally reported in the Amiga 1000 review (October 1986 BYTE, page 234) are in error. The correct times are presented here.

ing a jumper between three points on the daughterboard, and this operation cured the problem. Although the modification should be unnecessary on most Amigas, individuals who know their way around with a soldering iron should have no problems with it, although you should check with CSA to confirm that the patch is necessary before trying it. This is because there is no pattern to the problem: It can plague a new or an old Amiga 1000.

When the Turbo-Amiga and the Amiga 1000 are turned on in sequence, the Turbo-Amiga's 68020 processor takes control of the bus, disabling the Amiga's 68000. At this point, running the CSAMemon program included on the disk enables the memory in the Turbo-Amiga, allowing it to realize its full speed potential. You can modify the Startup-Sequence script file to call CSAMemon every time you boot the machine.

Performance

The Mandelbrot graphics program provided on the disk is a good example of the power of the 68020/68881 combination. A normal Amiga can plot the demonstration graphic in about 50 minutes; in contrast, the Turbo-Amiga runs it in about 3 minutes.

For more precise measurements of performance, I ran various benchmarks in three languages: FORTRAN, Modula-2, and the BASIC system tests normally performed for a system review. See page 000 for the BASIC benchmark results and table 1 for results of the FORTRAN and Modula-2 Sieve benchmarks. The "Products Used" text box provides more information on the compilers I used for the tests. Both the Amiga 1000 and the Turbo-Amiga had 512K bytes of internal memory and two disk drives, and I used Kickstart/Workbench 1.2 in all cases for consistency.

The Spreadsheet benchmark results hint at the kind of performance increase you can expect from programs not written expressly for use with the Turbo-Amiga, as was the case with the spreadsheet I used (Lattice's Unicalc 1.0). Not only did the Spreadsheet Recalculate run more than three times faster than normal, but the Spreadsheet Load time was cut by about two-thirds.

Benefits and Drawbacks

Most operations I performed with the Turbo-Amiga in place were noticeably snappier. Using the Command Line Interface (CLI) became much quicker and more responsive. Program compile times were reduced, although the compilers tested were restrained by the amount of necessary disk I/O. Adding one of the optional hard disks to the Turbo Chassis would help speed things up more, as would the addition of more memory to the unit.

One recurrent problem I had was software incompatibility; some of the operations that are performed by the 68000 without question are restricted in the 68010 and 68020. [Editor's note: *Such operations modify the status register, and Motorola made them privileged to properly support the virtual machine mode in the 68010 and 68020. A few of these operations are* `MOVE SR, <ea>`, `MOVE <ea>, SR`, `ANDI <data>, SR`, *and* `EORI <data>, SR`.] Executing a restricted instruction causes a `Software Error_Task Held` message, after which the computer resets itself. The few programs that had this problem were either old or from the public domain. Since Commodore has warned developers to keep code compatible with the 68010/68020 processors, this problem will most likely be short-lived. Some programs with this problem

continued

Products Used

Absoft (4268 North Woodward, Royal Oak, MI 48072, (313) 549-7111) makes FORTRAN and BASIC compilers for the Amiga, Atari ST, and Macintosh. Absoft lent me a copy of its FORTRAN/020 version 2.2d compiler for use with the Turbo-Amiga. FORTRAN/020 is a complete implementation of FORTRAN 77 for the Amiga and costs $495. It generates code optimized for the 68000 and 68020 microprocessors, includes a debugger, and has a library for use with the 68881 math coprocessor. It is source-compatible with Absoft's FORTRAN compilers for the Atari ST and Macintosh. I was pleased with the quality and ease of use of this product. If you purchase a Turbo-Amiga for number crunching or scientific applications, you should consider FORTRAN/020 a necessity.

The Modula-2 compiler I used was TDI Modula-2 version 2.20 (Developer's version) from TDI Software Inc. (10410 Markison Rd., Dallas, TX 75238, (214) 340-4942). It includes a complete library to interface with the Amiga's graphics, sound, and system routines. The compiler is available in several configurations: the Regular version ($99.95), the Developer's version ($149.95), and the Commercial version ($299.95). I had difficulty getting the Developer's version to work with the Turbo-Amiga; sometimes it ran smoothly, and other times it would cause a system crash. According to TDI, version 3.0 of TDI Modula-2, which is now shipping, works with a 68010 or 68020 processor.

Table 1: *FORTRAN and Modula-2 Sieve benchmarks. All times are in seconds. The two versions of the Sieve program used were identical except for the number of array elements. The Short Sieve (the version BYTE uses for benchmark tests) has an array size of 7000 elements, while the Long Sieve's 8191-element array is the same as that used in "Eratosthenes Revisited: Once More Through the Sieve," in the January 1983 BYTE. Absoft's FORTRAN/020 version 2.2d and TDI's Modula-2 version 2.20 (Developer's version) were used. Since there are no special provisions for using the 68020 or 68881 chips with the TDI Modula-2 compiler, the program was compiled and linked normally for both the Amiga 1000 and the Turbo-Amiga. When run with the Turbo-Amiga, Absoft's 68881 hardware floating-point math library (m81.rl) was linked to the program. For use on an Amiga 1000, the software floating-point library (f77.rl) was used. Both Sieve programs were modified to run 100 iterations (rather than the normal 10) to make measurement of execution speed more accurate. The execution times were then divided by 10 to provide the results shown.*

	Short Sieve		Long Sieve	
	FORTRAN	Modula-2	FORTRAN	Modula-2
Amiga 1000	5.6	5.9	6.5	6.9
Turbo-Amiga	1.0	1.4	1.2	1.7

are usable with the public domain DeciGEL program, which attempts to correct code with operations illegal to the 68010 and 68020. [Editor's note: *For more information on DeciGEL, see the review "Public Domain Software for the Amiga" by Warren Block in the February BYTE.*]

Another problem was that Amiga BASIC would not run correctly with the Turbo-Amiga enabled. For example, although Amiga BASIC would start properly, I could not load a file; instead, I got a `File not found` error message, even though the file existed. According to Commodore, the reason this error occurs is that Amiga BASIC uses only 24-bit addressing, and loading Amiga BASIC into a 32-bit address space on the Turbo-Amiga's memory board causes the errors. CSA provides ABasiC with the Turbo-Amiga for this reason, but it is incompatible with Microsoft BASIC. Since practically all the BASIC programs available in the U.S. are written with a Microsoft interpreter, this limits the availability of BASIC software.

You can use Amiga BASIC on the Turbo-Amiga by disabling the 32-bit memory, which is done by simply not running the CSAMemon program when you start the computer. However, I still found an Amiga BASIC program, ObjEdit, that caused crashes that didn't occur when the Turbo-Amiga was disconnected.

The Bottom Line

Rather than looking at the Turbo-Amiga package as an upgrade to the Amiga, it's more appropriate to think of it as an extremely high performance Amiga clone from another company. The Turbo-Amiga has some incompatibilities with the regular Amiga, such as the problems with Amiga BASIC, but the inability to use Amiga BASIC won't bother those who want to run only calculation-intensive programs in FORTRAN.

Although the combination of the Amiga and the Turbo-Amiga upgrade is somewhat high-priced for a microcomputer ($4965, which includes 512K bytes of 32-bit RAM for the Turbo-Amiga and a $1295 list price for an Amiga 1000), its performance is in the range of a much more expensive minicomputer. For example, compare the FORTRAN Long Sieve benchmark times in table 1 to those in "Eratosthenes Revisited: Once More through The Sieve" by Jim and Gary Gilbreath in the January 1983 BYTE; the combination of the Turbo-Amiga and Absoft's FORTRAN/020 beats all the times listed for the VAX-11/780 in the January 1983 article.

It is interesting to compare the Turbo-Amiga system to computers that use the new 80386 chip. [Editor's note: *For two examples of these computers, see the review "The ALR Access 386 and the Compaq Deskpro 386" by Stanley J. Wszola and Curtis Franklin Jr. in the February BYTE.*] In terms of performance, the Turbo-Amiga comes close to the 80386-based machines (29 seconds for the Sieve benchmark on the Turbo-Amiga versus 21 seconds for the Compaq Deskpro 386), and it adds the Amiga 1000's graphics capabilities to the battle.

Professionals in need of a well-made computer that combines the Amiga's graphics prowess with the sheer computational power of the 68020/68881 chip set should take a close look at the Turbo-Amiga. ■

Pick of the Litter

William H. Murray and Chris H. Pappas

With graphic user interfaces becoming more and more popular, a proliferation of companies are selling mice to traverse these interfaces. A mouse can simplify maneuvering around windowing environments, such as Microsoft Windows or DESQview, paint programs, or computer-aided design programs, such as AutoCAD. Companies have come up with ways to add mouse support to programs that were not originally designed to be used with a mouse.

We've compared features of eight different mice: the Microsoft Mouse ($175 and $195 for the bus and serial models, respectively), the Logitech Bus Mouse ($149) and C7 Mouse ($99), Mouse Systems' PC Mouse Bus Plus ($199), Summagraphics' SummaMouse ($119), and The Torrington Company's Manager Mouse models 1001C-IR ($229) and 1001C-KF ($179). See table 1 for a complete list of features.

These eight models are for use on the IBM PC, XT, AT, and compatibles; we tested all of them on an 8-MHz PC AT with 640K bytes of memory, an 8087 math coprocessor, and one serial port. We'll discuss the advantages and disadvantages of two- and three-button mice and compare mechanical versus optical operation, as well as corded versus cordless models. We'll also take a look at the usefulness of the bundled software. We've noted the number of ICs used to build the mice; fewer chips probably mean higher reliability. We tested the mice with a variety of software packages, including WordPerfect, dBASE III, Lotus 1-2-3, Reflex, Turbo Prolog, AutoCAD, Microsoft Windows, and DESQview. We had no trouble installing and running any of the mice with these programs.

Interfaces

Mice must have a hardware interface to the computer and a software interface to an application program. Each mouse comes with software that you install either at run time or boot time that tells application programs how to communicate with the mouse. The software controls the cursor position, and the mouse moves the cursor relative to the initial position at start-up.

Because the Microsoft Mouse was the first mouse for the IBM PC and compatibles to gain widespread use, its software interface has become the de facto standard. While other mice may provide an interface that is a superset of the Microsoft Mouse driver software, they all provide the ability to run software written for the Microsoft Mouse interface standard.

The hardware interface between the mouse and the computer falls into two categories—serial or bus. Most companies selling mice today offer both versions, and each has advantages and disadvantages. A serial mouse plugs into serial port 1 or 2 on the computer and sends data to the mouse software that the user installs. The serial mouse's speed of data transmission is limited by the data rate of the mouse software (1200 bits per second for all the mice we reviewed). The disadvantage of the serial mouse is that it ties up one of your serial ports. The advantage is that it's easy to move between computers: You simply unplug it from the serial port of one and plug it into the serial port of the other.

A bus mouse has its own interface card that plugs into a peripheral socket on the IBM PC, XT, or AT, so it does not tie up one of your serial ports. It transmits information in a parallel fashion. Its speed of data transmission is limited only by how fast the interface board can be polled, which is determined by the clock rate of the computer you are using. We found in practice that the faster speed of the bus mouse was not much of an advan-

continued

Table 1: *Summary of mouse features. Cord length sizes are in feet; pad sizes are in inches; resolutions are in dpi. For those mice where we reviewed two versions, the systems mentioned are compatible with both. The $149 price for the Logitech Bus Mouse now includes LogiPaint in addition to the other software listed. The Logitech C7 Mouse is also available bundled with LogiMenu, Click, M1-2-3 Shell, and Point for $119; for an additional $30, LogiPaint is included. The Manager Mouse 1001C-KF is available for $139 bundled with mouse-driver software only. In March, Mouse Systems introduced a new model of its PC Mouse Bus Plus, which, according to the company, is more reliable. It does not come bundled with PC Paint Plus and costs $179. Summagraphics now offers a SummaMouse that doesn't require an external power supply. Call the individual companies for the latest prices and configurations.*

Company	Name	Price	Type	Buttons
Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073 (206) 882-8080	Microsoft Mouse: Bus	$175	Mechanical	2
	Serial	$195	Mechanical	2
Logitech Inc. 805 Veterans Blvd. Redwood City, CA 94063 (415) 365-9852	Logitech Bus Mouse	$149	Optomechanical	3
	C7 Mouse	$99	Optomechanical	3
Mouse Systems Corp. 2600 San Thomas Expressway Santa Clara, CA 95051 (408) 988-0211	PC Mouse Bus Plus	$199	Optical	3
Summagraphics Corp. 777 State Street Ext. Fairfield, CT 06430 (203) 384-1344	SummaMouse	$119	Optical	3
The Torrington Co. 59 Field St. P.O. Box 1008 Torrington, CT 06790 (203) 482-9511	Manager Mouse: 1001C-IR	$229	Mechanical	3
	1001C-KF	$179	Mechanical	3

tage over the serial mouse, because moving a mouse fast enough to hit the 1200-bps limit is unlikely. A drawback of the bus mouse is that, to move it between two computers, you have to open the machine, pull out the interface card, and install it in the other computer.

Movement Detection

There are two ways in which mice can detect movement: by use of either a variable resistor or a data encoder. Of the eight units reviewed, the Microsoft Mouse is the only one that employs variable resistance. As the mouse moves, electronic circuitry detects a change in resistance because the trackball is connected to a potentiometer. The circuitry passes that information to the mouse software, which the user has already installed. The accuracy of the mouse is dependent on the linearity of the two variable resistors (one for horizontal and one for vertical directions). The disadvantage of a mechanical mouse is that the trackball can pick up dust and dirt from the desktop.

All the other mice use some sort of direct data encoding for detecting movement. This involves sending "make-and-break" signals from the mouse to the port—a digital form of encoding that tends to be more precise than the analog encoding of variable resistors.

A mouse can generate this make-and-break information in different ways. Optical mice, such as the SummaMouse and the PC Mouse Bus Plus, require a special pad for operation, and they detect motion by the interaction of a light beam and a detector, which are located in the mouse, with the reflection of the light from the grid pattern on the pad. Optical mice provide the most trouble-free operation, since there are no wheels or balls to get clogged with dust or dirt.

Optomechanical mice require no special pad for operation. In these mice, movement is transmitted to a rotating wheel that has a special code on it. The Logitech Bus Mouse and C7 Mouse, the only optomechanical mice of the eight, use an encoding wheel to chop a light beam, sending coded make-and-break information to the port. The Manager Mouse, which is purely mechanical, uses a similar concept, but, instead of a light beam, it uses an encoding wheel with a conducting metal pattern. Special spring wires rub against the conducting metal pattern and send the coded make-and-break information.

Microsoft Mouse

The Microsoft Mouse is a two-button mouse. Most vendors writing software with mouse support will make sure that their software works with the Microsoft Mouse. Also, most software available today requires only a two-button mouse; generally, software requiring three buttons is developed only by vendors of three-button mice.

Internally, the Microsoft serial and bus mice differ greatly, although both offer a resolution of 200 dots per inch. First, the serial mouse has two surface-mounted ICs that encode and send the information on mouse movement. The ICs are not necessary in the bus mouse because the separate peripheral board interfaces the resistor readings to the computer. These mice require only minor cleaning.

Logitech's Mice

With regard to hardware, Logitech's C7 Mouse is our favorite. This three-button mouse offers a resolution of 200 dpi. It has a high-quality rubber-coated trackball, just like that of the Microsoft Mouse, which moves easily over almost any surface. But, unlike that of the Microsoft Mouse, its trackball rotates two optical encoding wheels instead of variable resistors. The Logitech C7 thus offers the advantage of a smooth-rolling trackball, eliminating the need for a special pad to roll the mouse on, while giving the user the precision and reliability of an optical mouse. The C7 Mouse contains two ICs and has a 6-foot cord. Logitech's Bus Mouse has a peripheral board with 19 small ICs. The mouse itself contains one IC and has a 4-foot cord.

PC Mouse Bus Plus and SummaMouse

Both the PC Mouse Bus Plus and the SummaMouse are three-button optical

Interface	Power	Connector	Cord length	Pad size	Resolution	Systems	Additional bundled software
Bus	Internal	9-pin round custom	5	None	200	IBM PC, XT, AT; 100 percent compatibles;	Microsoft Paintbrush, Show Partner
Serial	Internal	25-pin and 9-pin D shell	5	None	200	IBM 3270 PC; Olivetti M24	Microsoft Paintbrush, Show Partner
Bus	Internal	9-pin D shell	4	None	200	IBM PC, XT, AT, and compatibles	LogiMenu, Click, M1-2-3 Shell, Point
Serial	Internal	9- or 25-pin D shell	6	None	200		LogiMenu, Click, M1-2-3 Shell, Point
Bus	Internal	9-pin D shell	5	7¾ by 9	100	IBM PC, XT, AT, and compatibles	PC Paint Plus, Designer Pop-up Menu
Serial	External	9- or 25-pin D shell	5	10½ by 9	100	IBM PC, XT, AT, and compatibles	None
Serial	External	25-pin and 9-pin D shell	Infrared	None	100	IBM PC, XT, AT, Compaq, and compatibles	Keyfree
Serial	Internal	9- or 25-pin D shell	5	None	100		Keyfree, TelePaint

mice, each with a resolution of 100 dpi. They both require a special surface to glide on, and they detect motion by the interaction of a light beam and a detector located in the mouse with the reflection of light from the special pad's surface. While the PC Mouse Bus Plus and the SummaMouse accomplish their motion detection in slightly different ways, the nonmechanical contact eliminates the threat of problems caused by dust and dirt. The PC Mouse Bus Plus uses a rigid metal pad with a specially coated surface. Our concern with this pad is that the surface might become scratched during rough use, causing tracking errors. The SummaMouse uses a flexible pad, and the instructions clearly warn that exposure to strong sunlight may cause the lines on this pad to fade, rendering the mouse useless, or leading to an unacceptably high number of tracking errors.

We do not like to use mice with special pads; a pad's limited size forces you to be aware of how close your mouse is to the border, thus restricting your movement. For long sweeps, your only option is to pick the mouse up, move it to the other side of the pad, put it down, and begin tracking again.

The PC Mouse Bus Plus that we used for this review came with a peripheral card containing seven ICs and one regulator. The cord on this mouse measured 5 feet. The SummaMouse that we reviewed was a serial version with one transistor, five ICs, and an internal crystal. It was also equipped with a 5-foot cord.

Manager Mouse

The Manager Mouse comes in two serial versions: one with a 5-foot cord, and one that transmits information via an infrared beam. These are three-button mice, both offering a resolution of 100 dpi. They have two small plastic wheels set at 90-degree angles to each other. One wheel detects horizontal motion, while the other detects vertical movement. The wheels connect to a rotor with a metallic coded pattern. We found that the small plastic wheels did not track easily over all surfaces. They sometimes slipped on extremely hard surfaces, such as glass, or became bogged down in soft materials, like felt.

The infrared transmitter in the model 1001C-IR is a creative concept in mouse freedom, although we question how useful it might actually be. The infrared mouse contains batteries that must be charged by the mouse receiver. The receiver plugs into the computer's serial port and also into a small power supply. The receiver is a small lightweight device containing one IC and one transistor along with the infrared detector. The mouse contains two infrared transmitters set at slight angles at the front of the mouse, one large IC, one transistor, and a set of rechargeable batteries.

During operation, we could position the mouse at just about a 90-degree angle to the receiver, and it still transmitted information correctly. Distances up to about 10 feet were acceptable. Background light levels did not affect this mouse. The mouse offered a few problems, however. First, the batteries must be kept charged by plugging the mouse into the receiver. If you forget to charge the batteries, the mouse will work with the charger plugged in, but then you must contend with its cord. The lack of a physical attachment to the computer also opens the potential of a lost or stolen mouse.

Software Concerns

All the mice reviewed came with easy-to-follow installation instructions. Standard software included a RAM-resident mouse driver. The mouse driver is loaded when you boot your system, and it remains invisible until an application calls for it. Several of the mice came bundled with additional software that may factor into your decision of which to buy. The Microsoft Mouse, PC Mouse Bus Plus, and Manager Mouse 1001C-KF each come with an excellent graphics program: Microsoft Paintbrush, PC Paint Plus, and TelePaint, respectively. These paint programs allow you to create graphic designs, charts, and labels and capture graphics images produced by other programs. You can then enhance a captured image with color, patterns, and

continued

labels of different sizes and font types. A graphics slide-show-type program called Show Partner is also bundled with the Microsoft Mouse. With Show Partner, you can enhance graphics created by other programs and select the order, timing, and presentation style of each screen.

The Microsoft Mouse, Logitech Bus Mouse, PC Mouse Bus Plus, and Manager Mouse 1001C-KF include software that lets you custom-design application-dependent pull-down menus. Special mention goes to the Logitech Bus Mouse, which has one of the most complete selections of predefined menus for such popular programs as Borland's Turbo Pascal and Turbo Prolog and Logitech's Click program, which detects the application you're using and automatically sets the mouse to your predefined settings. Each mouse also comes with an emulation-mode driver that enables it to interface with programs written only for the Microsoft Mouse.

Which Should You Choose?

All the mice passed some simple tests that we applied to them. To simulate dropping them off a desk, we dropped them three feet onto a concrete floor covered with a half inch of carpeting; they all continued to work. We rolled them through dust and dirt taken out of a vacuum cleaner, and they all continued to track properly. None of the mice were affected by bright ambient light, or by varying humidity levels.

We found that all these mice performed well and were reliable. Your decision of which to choose might be based on the number of buttons, whether you have a communications port available for a serial mouse, or whether you have a spare slot for the interface card of a bus mouse. Also, you need to decide whether you will use a mouse for applications that come with mouse support or whether you'll need to customize a mouse menu/button function.

We recommend either the Microsoft Mouse or the Logitech C7 Mouse. Both offer high resolution and proven performance, and both use an easy-gliding trackball that will roll over just about any surface. If you need a graphics program in addition to having a mouse, then consider one of the Microsoft mice or the PC Mouse Bus Plus. All three include excellent software for custom-designed mouse menu/button functions. ■

William H. Murray and Chris H. Pappas are professors at Broome Community College (Binghamton, NY 13902). They are currently working on a book about 80386 hardware.

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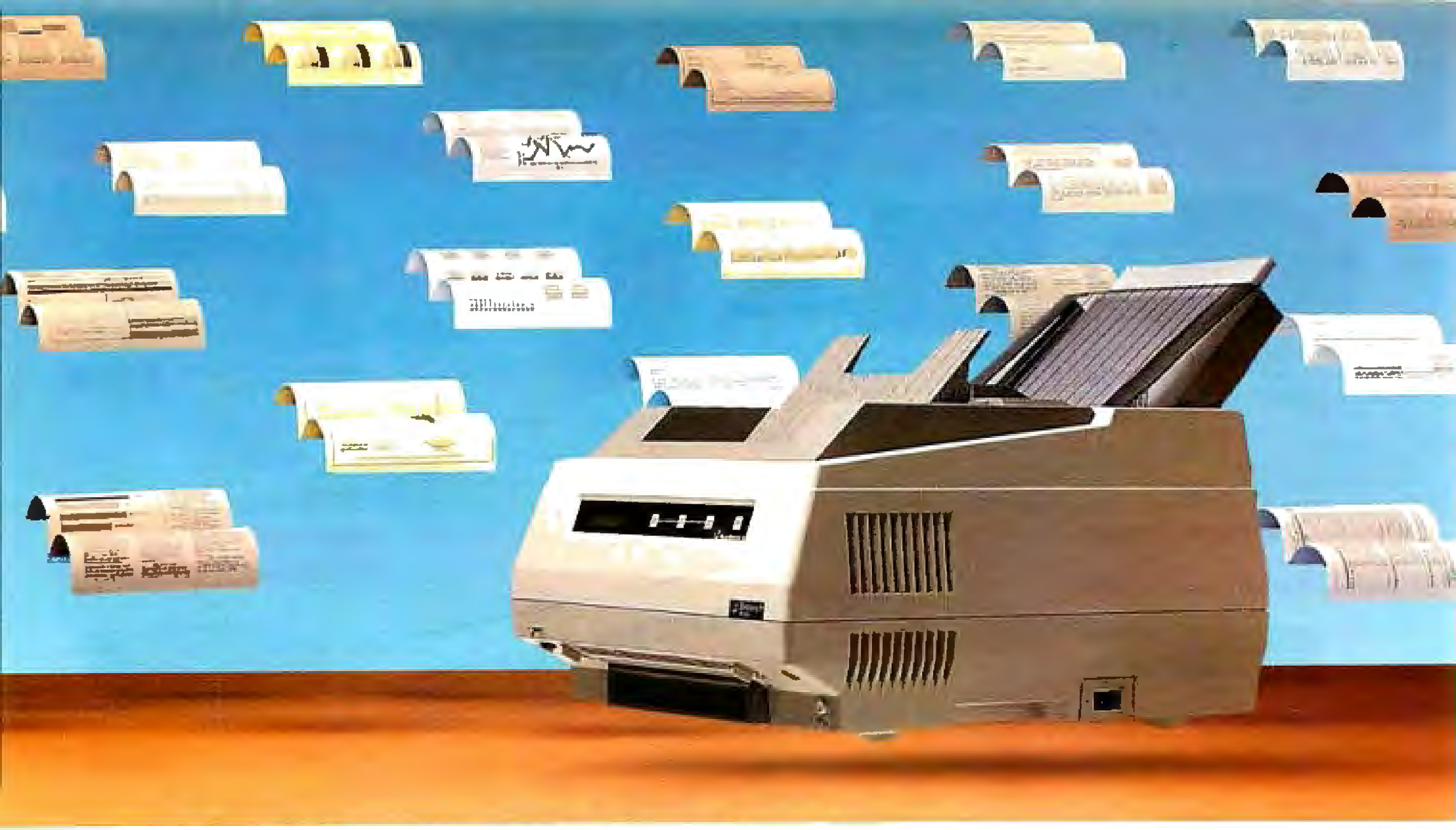

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Four C Language Interpreters

John Unger

An overview of Run/C, Run/C Professional, C-terp, and Instant-C

Run/C version 2.03 and Run/C Professional version 1.03 by Lifeboat Associates ($120 and $250, respectively), C-terp version 2.22 by Gimpel Software ($298), and Instant-C version 2.20 by Rational Systems ($495) are four C interpreters for MS-DOS machines. The packages are designed to accomplish the same general tasks, but the approaches they take and how they interface with the user are all distinct.

Run/C and Run/C Professional are essentially the same program. The major difference between them is that the Run/C Professional package includes the ability to load external object libraries and code. Because they differ only in this respect and because their interfaces, much of the content of their manuals, and their benchmark results are identical, throughout most of this review I will use one term, Run/C, to refer to both of these interpreters.

All four software packages are classified as interpreters. Instant-C can also produce a stand-alone executable file. However, only Run/C executes programs in a mode similar to most BASIC interpreters—interpreting each line of source code on a line-by-line basis without producing any intermediate code. This situation accounts for the relatively slow speed of Run/C in the benchmark tests. The other interpreters feature a compile mode, in which the source code is compiled internally into an intermediate code and then is run from this compiled form.

Instant-C and Run/C allow you to operate in a direct mode, which is similar to BASIC. This means that you can enter any valid C expression, including calls to library functions, while in the interpreter, and the result will be evaluated and displayed on the console.

Hardware and Software Requirements

The four interpreters are designed to run on the IBM PC, XT, AT, and compatibles and require at least one 360K-byte floppy disk drive for loading their software. All four packages run on MS-DOS 2.0 or higher.

Each of the interpreters requires a lot of free memory. C-terp requires 256K bytes of RAM, Run/C requires a minimum of 320K bytes, and Instant-C needs at least 512K bytes. None of the interpreters uses overlays. This means the entire interpreter, editor, library, and other required modules are all part of one executable file and load into memory at run time. Access to the various parts of the interpreters is fast, but your computer must have sufficient memory for the operating system, the interpreter, and your program. The maximum size of the source code you can load into any of the four packages is usually limited only by the amount of RAM you have. Run/C can handle a maximum of 640K bytes of RAM, C-terp can handle up to 16 megabytes of virtual memory (you activate this memory option by a command when you start the program), and Instant-C can manage a maximum of 1 megabyte of nonextended RAM, or an additional 64K bytes of expanded Lotus/Intel/Microsoft (LIM) memory.

All four interpreters use C syntax that is compatible with the Kernighan and Ritchie definition of the language. You can set up Run/C Professional, Instant-C, and C-terp to use libraries specific to either Microsoft or Lattice C compilers. C-terp also comes in versions that are compatible with Manx Aztec C, Computer Innovations' C-86, and Mark Williams' C.

None of the interpreters is copy-protected. All four user's manuals urge you to make backup copies of the distribution disks immediately. I had no problems copying any of the programs to a hard disk.

Overview of the Interpreters

The authors of Run/C strived to make their C interpreter look like the environment familiar to users of Microsoft BASIC interpreters. Most of the commands closely follow those used in BASICA and GW-BASIC. The in-memory full-screen editor has many of the features and uses the same keystrokes as the popular WordStar editor.

C-terp moves further away from familiar patterns and provides an integrated environment of a menu-driven command level, a powerful screen-oriented editor with line numbers, and a debugger.

Instant-C is the most sophisticated of the four packages. It provides all the features of the other interpreters plus a few extras. Instant-C lives up to its name as far as speed of program compilation and execution is concerned; it was by far the fastest in the benchmark tests.

All four packages are designed to execute C source code only from within the confines of their individual interpreters to produce the desired output. What good are they, then? I think that there are two principal roles they might play: as a tool for learning how to program in C or as a tool for quickly writing portable C programs that you will later compile into executable programs. The least expensive package, Run/C, is especially good if you're a beginner in C and are familiar with the screen layout and operation of GW-BASIC or BASICA.

All four packages' user's manuals provide good descriptions of how to get the programs running on your computer and take you step by step through a simple example program. Each manual provides

continued

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	RUN/C version 2.03 RUN/C Professional version 1.03	C-terp version 2.22	Instant-C version 2.20
Type	C language interpreters	C language interpreter	C language incremental compiler
Company	Lifeboat Associates 55 South Broadway Tarrytown, NY 10591 (914) 332-1875	Gimpel Software 3207 Hogarth Lane Collegeville, PA 19426 (215) 584-4261	Rational Systems P.O. Box 480 Natick, MA 01760 (617) 653-6194
Format	Two 5¼-inch floppy disks	Two 5¼-inch floppy disks	Three 5¼-inch floppy disks
Computer	IBM PC, XT, AT, or compatible with at least one 360K-byte floppy disk drive and 320K bytes of RAM running DOS 2.0 or higher	IBM PC, XT, AT, or compatible with at least one 360K-byte floppy disk drive and 256K bytes of RAM running DOS 2.0 or higher	IBM PC, XT, AT, or compatible with at least one 360K-byte floppy disk drive and 512K bytes of RAM running DOS 2.0 or higher
Documentation	530-page user's manual	148-page user's manual	520-page user's manual
Price	Run/C: $120 Run/C Professional: $250	$298	$495

you with a listing of the files on the distribution disks and describes the ones you will need to run the interpreter. All the manuals have tables of contents and indexes to help you locate specific subjects.

The amount and usefulness of the documentation supplied with the interpreters vary considerably. Run/C has the best manual of the lot. Nearly 400 of the manual's 530 pages contain descriptions and meaningful examples of how to use all the 115 library functions included with the interpreter. This is in sharp contrast to C-terp's 66 functions, which are described without examples in 50 pages of its user's manual. Instant-C's manual contains almost 300 pages of terse descriptions of its extensive collection of 162 library functions and has only a few short examples.

Although complete at 430 pages, the Instant-C manual is difficult to use and confusing, mostly because it is difficult to locate specific information on the interpreter's commands and functions, despite the manual's index. Instant-C is a large, sophisticated program with no on-screen help. Fortunately, a well-written chapter in the manual that contains an example showing how to create, edit, and debug a program helps to overcome some of these difficulties. Anyone starting out with Instant-C should read this chapter first.

The Run/C Interpreter

When you start Run/C, you are greeted by a familiar-looking screen layout that mimics that of Microsoft BASIC: 10 highlighted boxes appear across the bottom of the screen to show the commands that are assigned to the function keys. Run/C's editor also has easily accessible help screens that are just a keystroke or two away.

You use the `LOAD` command to get an existing file from your disk. The `FILES` command allows you to see the files in the default directory. These and similar BASIC-like commands make it easy for someone who has used BASIC to get started with Run/C. Run/C's debugging aids consist of the `TRON` and `TRACE` commands, along with the ability to `DUMP` the values of variables after halting the program with Control-C or Control-Break. The `DUMP` command displays these values on the computer's screen; a corresponding `LDUMP` command dumps the values to a printer.

The aspect of Run/C that I found most bothersome was its rather slow execution speed. You can't do much about this, except to use the program on a faster microcomputer. Run/C also has sluggish disk I/O that makes the interpreter a bit tedious when loading large files from or saving them to disk. Beginners may not become as frustrated with Run/C's slow speed as I did, but I think it's fair to say that the slow execution of source code will render Run/C unfit for use by experienced programmers. [Editor's note: *The latest version of Run/C Professional is 1.11. This new version offers support of the Microsoft C 4.0 compiler's features.*]

C-terp

C-terp first appears on the screen as a menu, giving you a choice of 14 operations. Most choices are obvious, such as `LOAD`, `COMPILE`, `EDIT`, or `RUN`. To choose a command, you need only type its first letter, which is highlighted on the menu. A normal sequence would be to load a file with C source code from disk, edit it to make changes or just to preview the code, and then compile and run the program. Each of these operations takes just one keystroke, with the exception of typing in the name of the file.

The screen-oriented editor is fast and has most of the features that programmers have come to expect from editors, including block moves and copies, but it lacks macro commands and auxiliary buffers. An Alt-H keystroke combination instantly displays a helpful menu of editor commands on the screen. You use line numbers for the editor, and they act as a handy reference for the debugger and error messages. The line numbers are not saved as part of the file.

C-terp allows you to set breakpoints anywhere in your source code by use of a `breakpt( )` function. This function serves as an entry point into the debugger. In the debug mode, you can display or change the value of any active variable and then continue execution of the program. A split-screen feature shows the source code in the top half of the screen, with the debugger commands and their results in the lower half. You can also flip back and forth to a screen showing the program's output or browse through the source code without ever leaving the debugger.

A major shortcoming of C-terp is its lack of a built-in library of mathematical functions, such as sine, tangent, or square roots. Normally, C is not looked upon as a language for writing scientifically oriented software, but I have used it for this purpose and routinely write scientific programs in C rather than in FORTRAN. You can overcome this lack of mathematical functions if you have access to C source code for the math functions you need, and you can include this code with your program.

Another alternative is to use an object code math library that is compatible with C-terp. If you already use a C compiler, this solution is easy because C-terp comes in versions that are compatible with Manx Aztec C, Lattice C, Computer Innovations' C-86, Microsoft C, and Mark Williams' C. With the Microsoft-compatible version of C-terp that I tested, I was able to create a version of C-terp that used all the Microsoft compiler's library functions. This feature allows you to use the interpreter to test programs that you can later generate into executable files with your compiler. [Editor's note: *The latest version of C-terp is 2.30B. It now supports the keyword* `far` *for large memory-model addressing, as well as ANSI extensions to the C language, such as function prototyping.*]

Instant-C

Instant-C is unique among the interpreters in that it gives you the capability to create stand-alone executable files. However, the executable module produced includes the entire Instant-C library code (which is larger than 32K bytes), along with all the storage allocated by Instant-C to your source code during the debugging session, unless you follow special procedures.

Instant-C has a variety of debugging aids and offers elaborate control over execution of your program. As with C-terp, you can set breakpoints anywhere in the source code with a `_( );` function, and you can examine and change variables once the debugger is entered.

This interpreter was difficult for me to understand and use, compared to the others. First, most of the user's manual is hard to read; for example, it informs you that you can edit a *function* (e.g., `main( )`) only after you have loaded the *file* into memory. However, this vital bit of information lurks in a section entitled "Style Differences," which follows the introductory section on the editor. Furthermore, the description of the `#load` command is located in yet another section entitled "The Instant-C Work space."

Second, the program itself is distinctly user-unfriendly and has no on-screen help; you must rely on the manual and your memory. After the program is invoked, the only thing that appears on the screen is a # prompt, not a menu. Instant-C has a total of 65 valid commands that you can enter from the interpreter mode. This gives you a great deal of control over editing, testing, and debugging your code, but it also gives you a great number of keywords to remember.

The program is particularly powerful for debugging and provides the programmer with a good set of tools for unraveling problems. However, Instant-C's true forte is the speed at which it executes C programs; it is clearly in a class by itself in this category. Instant-C also includes the largest library of built-in functions for programmers to take advantage of. For example, it has a number of commands for displaying memory in hexadecimal, octal, or decimal format. The math library provides exotic transcendental functions, such as hyperbolic cosine. A `setjmp` function is provided, as well as interrupt support to invoke MS-DOS functions.

Performance Evaluation

Because both C-terp and Instant-C compile the complete source code into an internal form before executing the program, I expected to see large differences in execution time between them and Run/C, which operates as a true interpreter. Clearly, as shown in the benchmark results in table 1, Instant-C is the fastest of the four, with C-terp in second place. Run/C was the slowest in all the benchmarks. Run/C and Run/C Professional performed virtually identically in the tests. To give you an idea of how the C interpreters compare to a standard C compiler, I have included the results of the benchmarks run on version 4.0 of the Microsoft C compiler. I ran the benchmark programs as functions called from within a `main( )` function. The `main( )` function included code to start a system timer, run the benchmark program, and then read and display the elapsed time.

However, the times shown in table 1 aren't the only factors to consider when choosing an interpreter. Programmers spend much of their time editing and debugging source code that they have created; usually only the end user gets the benefits of fast execution. The speed with which a programmer can produce C language code that executes flawlessly is clearly the important benchmark to consider if you choose to operate in an interpretive environment. On the other hand, the speed with which you can learn C syntax and instructions and begin to write real C source code is a key benchmark measurement for someone trying to learn the intricacies of the C language. In this sense, Instant-C is not as clear a winner, nor is Run/C as clear a loser, as the benchmark times would indicate.

As an attempt to compare the four interpreters in a fair way, I used the scenario in which you finish entering a program using the interpreter's editor and then proceed to debug and run the source code. First, I took a simple C program (see listing 1) that ran identically on the four interpreters. I then introduced two types of common errors into the source code. Table 2 gives an explanation of the error types used. I will refer to code in the program by line number and to error types by their code names, for example, S2 for syntax error number 2.

For error S1, Run/C prints out an error code, the offending line number, and the message `Variable or function fohr not found`. The compile-time errors S2 and S3 frequently are not obvious to compilers or interpreters until a line or so later or, in the case of a missing left brace, until the end of the program. Run/C did not handle error S2 well at all,

continued

Table 1: *Benchmark times for the interpreters and the Microsoft C compiler (for reference). Times are in hours:minutes:seconds. The Sieve test measures how long it takes to run ten iterations of BYTE's Sieve of Eratosthenes prime-number benchmark on an array of 8190 numbers. Sort tests each compiler's handling of pointers during a sorting operation. Fib tests the efficiency of each compiler's recursion while computing a Fibonacci series. Float measures the time it takes to do 140,000 floating-point multiplication and division operations. Fileio exercises the I/O functions of the compiler by reading and writing to a 65,000-byte disk file. An IBM PC with 512K bytes of RAM was used for the benchmark tests.*

	Microsoft C 4.0	Instant-C 2.20	C-terp 2.22	Run/C 2.03
Sieve	11	40	59:37	5:29:33
Sort	20	1:10	46:27	3:53:26
Fib	1:16	3:49	3:04:52	15:15:28
Float	1:33	8:09	16:29	51:58
Fileio	7:20	10:49	23:10	1:21:58

Table 2: *Type and location of the errors that were introduced into the program in listing 1. The first three, S1, S2, and S3, are simple syntax errors. The latter two, L1 and L2, are errors that can be detected only while the program is running.*

Error code	Type of error	Location in listing 1
S1	misspelled variable name	fohr for fahr—line 11
S2	missing ;	end of line 11
S3	missing { and }	lines 10 and 13
L1	integer instead of floating-point division	line 11
L2	integer instead of floating-point format in printf statement	line 12

Listing 1: *A simple program that demonstrates how the three interpreters handle syntax and run-time errors. The lines have been numbered for referencing in the text.*

```
 1  #define UPPER    300.0     /* upper limit of Fahrenheit degrees */
 2  #define LOWER    0.0       /* lower limit of Fahrenheit degrees */
 3  #define STEP     20.0      /* step to increment Fahr. degrees   */
 4
 5  main( )
 6  {
 7      float fahr, celsius;
 8      printf("\t\tFAHRENHEIT    CELSIUS\n\n");
 9      for (fahr = LOWER; fahr <= UPPER; fahr += STEP)
10      {
11          celsius = (5.0/9.0) * (fahr-32.0);
12          printf("\t\t%4.0f\t\t%6.1f\n", fahr, celsius);
13      }
14  }
```

and it produced the message Required lvalue not found. S3 produced the message **Error: unmatched braces** with the line number of where the last left and right braces were found. The only way to untangle run-time bugs like L1 and L2 is with a debugger or by sprinkling calls to the printf function throughout the source code to examine the values of variables. With the L1 error, the program compiled well and listed the values of fahr correctly, but the output of the variable celsius was all 0.0s. For L2, the output of both variables was 0. Run/C has two ways of debugging run-time errors: You can turn on a TRACE command toggle, or you can interrupt the program with a Control-C. This will interrupt Run/C and print the menu Continue, dump, ldump, interactive, help or end (C/D/L/I/H/E)? on the screen. The dump option lists all the variables and their values from three different areas: automatic variables declared in the function where the break occurred, automatic variables from the calling function, or all global and static variables. Prior to running the program, you can turn on the TRACE toggle, which prints out the current values of all the variables each time they are referred to as the program runs. Run/C also has a TRON/TROF command pair, which is similar to BASIC, to trace program logic and aid in debugging. These error messages and debugging aids are adequate, but a cut below what C-terp and Instant-C offer.

Both C-terp and Instant-C handled syntax errors easily and in a similar manner. For the S1 error, C-terp prints an error code and the message Undeclared identifier. Hitting any key puts you back into the screen-oriented editor with the cursor at the first letter of the word that caused the error.

C-terp handles both the S2 and S3 errors very well. For the S2 error, it gives the message Expecting ';' and places the editor cursor at the first character in the line following the omitted ;. For the S3 error, it gives the message expecting 'identifier' for a missing left brace and the message expecting '}' for a missing right brace . As with Run/C, the L1 error compiled but produced 0.0s for the variable celsius; I obtained similar results for L2. This was a good place to try C-terp's breakpt( ); function, so I inserted it within the for loop after line 12. The effect of having this function in the loop was that execution stopped just after the printf function was called, and the program automatically exited to the debugger screen.

In C-terp's debugger environment, the top two-thirds of the screen contains a listing of the program's source code where the breakpt( ); function is set. The bottom part of the screen displays a menu of commands for displaying variables, tracing, or stepping through code. You can select the appropriate command by typing its first letter. For example, hitting the *D* key selects the Display option and causes the debugger to print the prompt expression:, to which you can respond with the name of any valid variable and press Return. The current value of that variable is then displayed.

Instant-C makes it virtually impossible for you to leave the editor without compiling your source code function in its most recently edited form. The compiler handles all syntax errors logically and with somewhat more chatty messages than the other interpreters. For example, error S1 results in the message I'm sorry but I don't know the word ''fohr'' and the cursor was placed at the first character in fohr. For error S2, it displays the message Missing semicolon (;) before ''printf'' and the cursor was placed at the first character in printf. S3 produces the message I'm sorry, but I don't know the word ''{'' for a missing left brace and Missing closing brace (}); possible unterminated remark for a missing right brace. As with Run/C and C-terp, errors L1 and L2 generated 0.0s for the output.

You can track down run-time errors such as L1 and L2 with a variety of debugging tools. Instant-C's special __( ); function serves as a breakpoint to halt program execution and is similar to C-terp's breakpt( ); function. When you break out of a running program in Instant-C, the fragment of source code surrounding the __( ); appears in a window at the top half of the screen, and you are back in the command mode with a # prompt in the bottom half. From this prompt, you can issue special commands to view and change variable values and list the source code or reenter the editor mode and view the source code. But you cannot browse through the source code, as is possible in C-terp's split-screen debugger, nor do you have any on-screen aids to help you choose commands.

Technical Support

The support I have received from Lifeboat Associates, Gimpel Software, and

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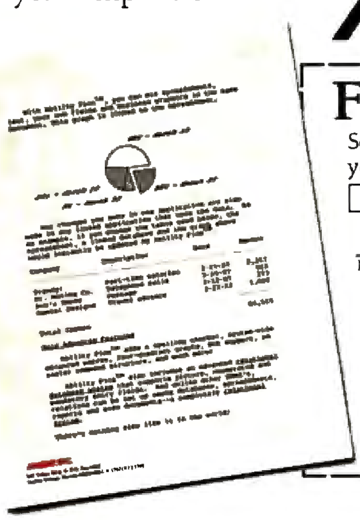

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Rational Systems has been excellent. All my questions have been answered quickly, accurately, and, in many cases, by the person who actually wrote the program. None of the companies has a toll-free number for technical help, but, instead of that convenience, you get a much more important one: no long waits or being told that someone will call you back. It is simply courteous, quick service. This situation may change as the number of users for the software grows, but I hope not.

Rational Systems has a service for Instant-C that I've never seen before with any other software I've used. It includes a stamped, self-addressed envelope with the documentation for you to use to send back bug reports or questions. Also, Rational Systems offers a money-back guarantee for the first 31 days you own the software.

Which to Choose?

Without a doubt, the best C interpreter I can imagine would combine features found in all four software packages reviewed here. First, it would have the documentation and editor of Run/C. Second, it would present you with an easily accessed menu-driven environment and an easy-to-use symbolic debugger like C-terp's. Third, it would have the speed, sophisticated features, and extensive library of Instant-C.

Of the four interpreters, C-terp comes closest to this ideal right now. Its only major shortcomings are the lack of an in-program math-function library and the terseness of some of its documentation.

Run/C is an excellent package for beginning C programmers. I would recommend it particularly to those who are familiar with BASIC and who won't be put off by the slow execution speed. Run/C's low cost makes it especially enticing. Run/C Professional, with its ability to load external object libraries and code, adds more power to the basic Run/C package but does not improve on its execution speed.

The performance of Instant-C is excellent. However, the problems I had understanding how the software worked and its awkward documentation detract from the usefulness of the package. I cannot recommend Instant-C to beginning programmers, but experienced C programmers would appreciate and utilize its sophisticated features and power.

A big plus for C-terp and Instant-C is their ability to create versions of the interpreter that are completely compatible with the libraries of popular C compilers. In the case of Run/C Professional, you at least have the option to load and include different object libraries with the programs you are creating. ■

Microsoft Windows Software Development Kit

David and Lee Hart

The Microsoft Windows Software Development Kit version 1.03 ($500) is a set of libraries and utilities (see table 1) that you can use to give an application a window-based iconic user interface. These libraries let you create multitasking, device-independent applications and provide virtual memory management for them. The system also has two facilities for giving your programs the ability to exchange data: the Clipboard and the Dynamic Data Exchange protocol.

The development kit is designed to work with the Microsoft Windows operating environment, PC-DOS or MS-DOS 2.0 or higher, 512K bytes of memory, a graphics monitor, and a graphics adapter card, such as a CGA or EGA. Other graphics adapters will also work as long as they have a Windows device driver. Technically, you can run the system with two floppy disks, but Microsoft recommends using a hard disk. Windows runs sluggishly on any machine slower than a PC AT with a 20-megabyte hard disk drive. Microsoft strongly recommends using a mouse; you cannot use the Dialog, Font, or Icon editors without one.

Debugging with Symdeb, the symbolic debugger, requires an external console or a monochrome monitor with a display adapter in addition to the graphics adapter. The development kit also requires a language compiler with Windows support. Windows support means that the compiler supplies prologue and epilogue code to a program's segments to give the memory manager the information it needs to relocate or swap these segments to disk. The compiler must be able to specify Pascal-calling sequences, as all routines called by Windows use that convention. Four Windows-compatible compilers are available: Microsoft C 4.0, Lattice C 3.2, Microsoft Pascal 3.31, and the Microsoft Macro Assembler (MASM) 4.0. Examples in this article are written for the Microsoft C compiler.

Windows Architecture

A Windows application sees Windows support as a layer that lies between the operating system and the drivers that consists of three main sections: the Kernel, the Graphics Device Interface (GDI), and User (see figure 1). The Kernel handles the system-level chores of multitasking and memory management. The GDI handles output to the display and printer. It also isolates you from the details of specific hardware through the use of generalized drawing commands across all devices. User, the user-interface portion of Windows, handles the specifics of dialog boxes, pull-down menus, and scroll bars.

The Windows development kit gives you the tools you need to create Windows applications. A Windows application is a task that sits in a loop, polling the message system for messages and responding to them. Messages can be generated by the clock, mouse, keyboard, or by other tasks. A task may or may not have a window; one that does must also have a window procedure that interprets messages sent to the window. Tasks can send messages synchronously to the application queue with `PostMessage` or asynchronously directly to the window procedure with `SendMessage`. `PostMessage` returns without waiting for the corresponding window to process the message, whereas `SendMessage` doesn't return until the message is processed.

Figure 2 shows the structure of a Windows application. Every task must have a task-entry point, called `WinMain`. `WinMain` initializes an application's data, registers the application's window class, creates and displays the windows, and enters the message loop. It then uses the message function `GetMessage` to retrieve messages from the application's queue. `GetMessage` yields the processor to other applications when other programs are waiting. `WinMain` then translates and dispatches the messages to their respective window procedures.

All communication in a Windows application is accomplished by sending messages. The information transmitted in a message includes the handle of the target window; the message number; the parameters, `wParam` and `lParam`, which carry extra information specific to the message; the time at which the message was sent; and the mouse position. Mnemonic names for messages, as well as Windows-specific types and structures, are defined in the header file WINDOWS.H.

For each action or event that affects a window, there is an appropriately named message to inform the application. For example, when you select a command from the system menu, your program gets a `WM_SYSCOMMAND` message, indicating which command was chosen. You can then take some application-specific action or just take the default for that message.

If a message is received that the program doesn't need to process, it is passed on to the default window procedure, `DefWindowProc`, which carries out an appropriate default action. For example, `DefWindowProc` handles `WM_PAINT`, which means part of the window needs to be redrawn, by painting the entire window with the background color. `DefWindowProc` can change as Windows changes. This way, Microsoft can add new messages to future versions of Windows while retaining compatibility with older Windows applications.

A typical scenario for exiting the message loop is choosing `Close` from the system menu. This initiates a call to `DestroyWindow`, which generates the message `WM_DESTROY` for the application's queue. Your window function could then respond to `WM_DESTROY` by calling `PostQuitMessage`, which places a `WM_QUIT` message into the application queue. When `GetMessage` sees the `WM_QUIT`, it returns a zero (for all other messages, it returns a nonzero number), causing the program to exit the message loop and terminate.

Compiling

Figure 3 shows the process of compiling a Windows application from the C source files. The C compiler compiles the source code into the object file; resources, such as icons, cursors, fonts, and dialog boxes, are listed in the resource script file. The resource compiler uses this file to create the resource file.

The Windows linker, Link4, then combines one or more object files from the compiler into an executable file according to the module definitions file. This file is an ASCII text file that specifies the size of the program's heap and stack, the names of functions that are exported (so that Windows can call them), whether the program's code is shareable (so that several instances of the program running at the same time use the same code), and whether Windows can move the code and data around to make room for other programs. The executable file produced by Link4 has everything but the resources in it.

The last step is to use the resource compiler to add the resource file to the executable file from Link4. The result is a Windows format executable file. Windows format executable files are intended to be started from within Windows. If you start a Windows program from DOS, it displays the message `This program requires Microsoft Windows`.

You can automate all the steps for compilation by building a make file for the program-maintainer utility, Make, that describes all the necessary actions. This saves you from having to remember all the steps involved in compiling each time you modify your program, but compiling still takes a long time.

On a 4.77-MHz PC XT compatible with a 20-megabyte hard disk, we found the compile-cycle time to be just over 5 minutes for a 21K-byte C source file with two resources, a 1K-byte icon and a 270-byte cursor. That is a long period to wait

continued

Table 1: *The major components of the Windows Software Development Kit. Two versions of the executable files are available: one for debugging and one for normal operation of your application. Windows retails for $500; you will also need to purchase the Windows Operating Environment, one or more of the Windows-compatible languages, and a text editor.*

Executable windowing support
Kernel
User
Graphics Device Interface

Library files
Small, compact, medium, and large versions of the C library files;
Pascal library files

Include files

WINDOWS.H	(C language)
STYLE.H	(C language)
WINDOWS.INC	(Pascal)
CMACROS.INC	(Assembler macro file)

Must be purchased separately
Windows 1.03 text editor
One or more of the following:
Microsoft C version 4.0
Lattice C version 3.2
Microsoft Pascal 3.31
Microsoft Macro Assembler 4.0

Sample C programs
hello, cardfile, clock, fonttest, mapmodes, motion, shapes, template, track, type

Sample Pascal program
muzzle (template for application)

Utilities
Running under Windows:
Iconedit (requires mouse)
Dialog (requires mouse)
Fontedit (requires mouse)
Heapwalk
Shaker

Running under DOS:
Link4 (makes Windows executable)
Make (program maintainer)
RC (resource compiler)
Symdeb (debugger)

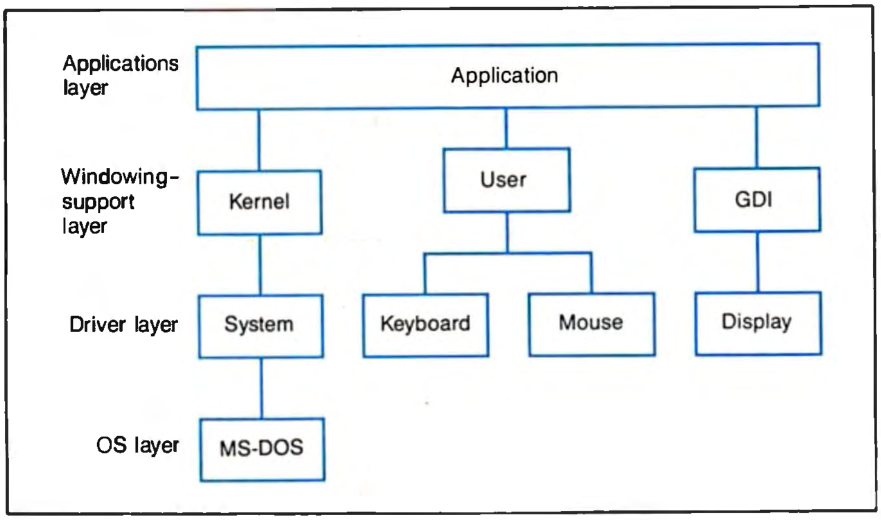

Figure 1: *The architecture of Windows as seen from an application.*

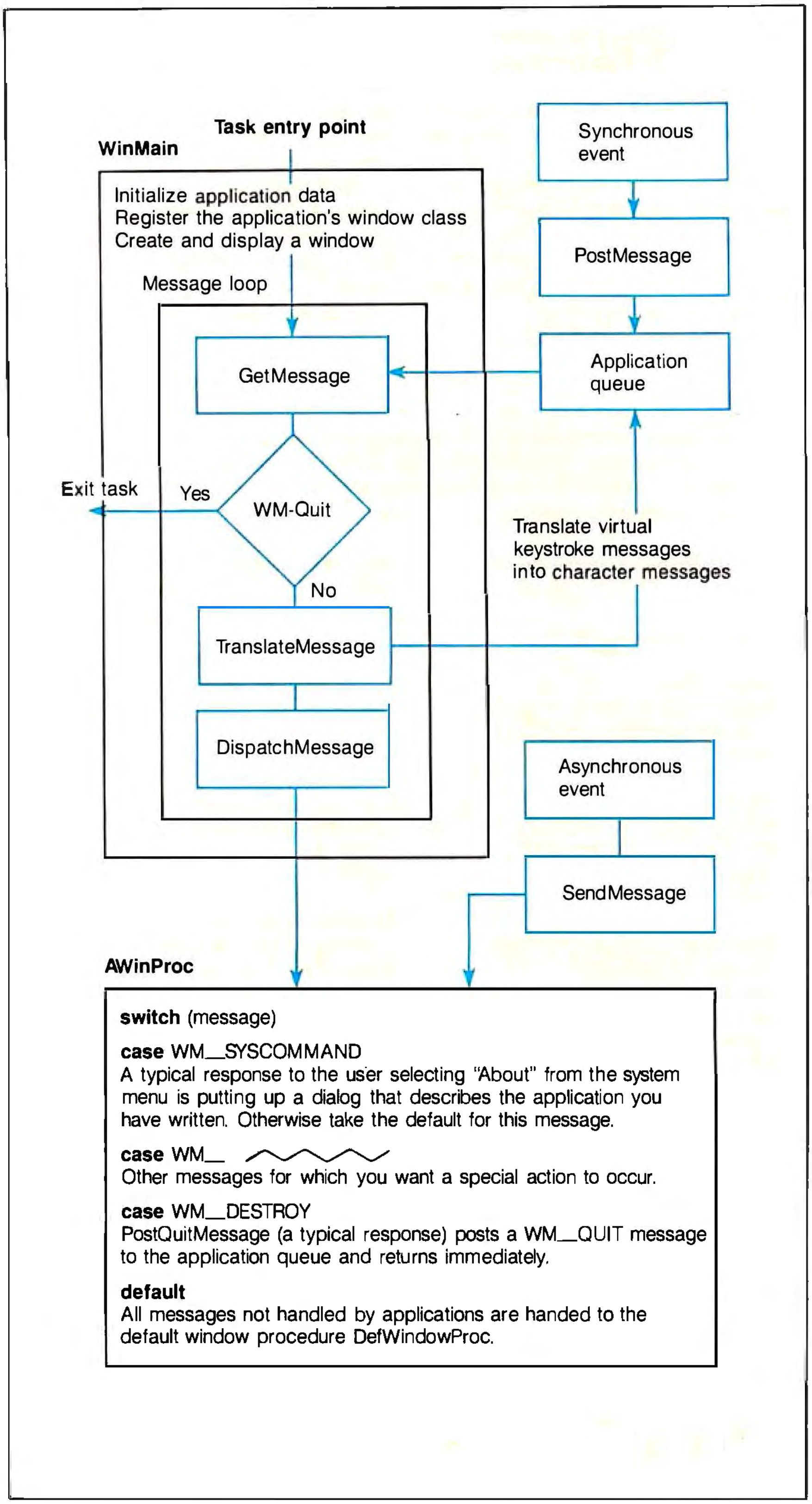

Figure 2: *Every Windows application must have a* `WinMain` *procedure, which serves as the entry point to the task.* `WinMain` *sets the stage for the application and then supervises the removal of messages from the application queue and the distribution of messages among the application's windows.* `PostMessage` *returns without waiting for the corresponding window to process the message;* `SendMessage` *doesn't return until the message has been processed.*

each time you make a change. The cycle is much more manageable with a PC AT compatible. On an 8-MHz PC AT clone with a 40-megabyte hard disk, the time for compiling the same application was under 2 minutes. Much of this time is spent plowing through WINDOWS.H, an 80K-byte header file that must be included at the beginning of C language source files to gain access to Windows's types, structures, constants, and functions. You can shorten the compile cycle substantially by making a custom version of WINDOWS.H for each application that you are compiling and cutting out all definitions dealing with any features your program doesn't use, such as sound, kanji characters, scroll bars, or serial communications.

Utilities

The utilities shown in table 1 that run under DOS are typical of utilities that DOS programmers have always used. The utilities that run under Windows, however, are more like those that a Macintosh developer might use. Every Windows application has an icon that represents it when its window is collapsed. You create these icons with Iconedit. Iconedit gives you a large window in which you design your icon by toggling bits on or off. Simultaneously, another window shows the actual-size icon that is the result of the pattern you are creating. You can also use Iconedit to create any nonstandard cursors that your program uses.

You can use Fontedit to create custom fonts for your Windows applications. You cannot edit the fonts included with Windows using Fontedit, however, since those fonts are distributed in a compiled format.

You can create dialog boxes by hand and specify them in the resource script file or on-screen using the dialog box editor, Dialog. The dialog editor allows you to prototype dialog boxes on-screen, which is considerably easier than planning them on paper and typing in specific (x,y) locations and sizes for each element. Dialog produces an ASCII dialog description that you can include in the resource script file.

Heapwalk displays each block of memory, giving the size of the block and the name of the program that allocated the memory. This information is useful when debugging a program that may have bugs in its memory management.

The Shaker utility torture-tests the integrity of a program's memory management by allocating and freeing up blocks of memory. This forces all other programs running at the same time to move

continued

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Microsoft Windows Software Development Kit version 1.03

Type
Libraries and utilities for making stand-alone Windows applications

Company
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Format
Seven 5¼-inch MS-DOS disks

Computer
MS-DOS- or PC-DOS-based machine with a graphics monitor, 512K bytes of RAM, DOS 2.0 or higher, two double-sided floppy disk drives or one floppy disk drive and a hard disk drive (recommended), and a graphics adapter card; mouse recommended

Language
Microsoft C; Microsoft Assembly

Documentation
Programmer's Utility Guide; *Programmer's Reference*; *Update to the Programmer's Reference*; *Programming Guide*; *Application Style Guide*; *Quick Reference*

Price
$500

around in memory. This movement will cause your system to crash.

Device Independence

The GDI gives applications a large degree of device independence by acting as a layer between the application and the hardware. The main benefit of the separation of the program from the hardware is that a Windows application requires no modification to work with any display device or printer that has a Windows driver. The same program that runs on an IBM PC with a CGA and an Epson printer will run on a Compaq 386 with a super-high-resolution screen and a laser printer. The GDI and its device drivers handle the transformations. If necessary, you can query the GDI to find out specifics of a hardware device, such as resolution of a screen or the colors available on a printer, but, in most cases, the GDI's transformations are adequate.

This device independence has another benefit: As graphic coprocessors become more common in display adapters, Windows programs can readily take full advantage of them, since most devices will come with Windows drivers. Already companies are working on using the Texas Instruments 34010 graphics coprocessor in graphics boards so they will work with Windows applications. Renaissance GRX has announced one such board, the Rendition I, which makes the Windows operating environment from 23 to 91 times faster for EGA mode.

Data Exchange

Windows has two types of data exchange. If you are familiar with the Macintosh, you probably know about the Clipboard, a holding place for data. You can cut or copy text or graphics from one document and then paste it back into the same document at a different place or into another document. The handy Clipboard makes integration of different programs a snap.

Dynamic Data Exchange (DDE) is a protocol developed by Microsoft for message-passing between applications. Using DDE, a spreadsheet would notify a graphing program each time a cell's content changes so the associated graph is kept current. Similarly, the graphing program would notify the word processor each time the graph changes. In this way, changing a spreadsheet would automatically update the graph in a word-processing report. The DDE protocol is not described in the Windows manuals, but the definition of the standard is available from Microsoft.

Memory Management

Windows's sophisticated memory manager allows dynamically loaded and linkable program code, data, and resources. You can move code, data, and resources around to group all free memory together or discard them when free memory is low. When a discarded code segment or resource is needed again, it is automatically reloaded from the disk.

This means that you can run a program that is larger than available memory if you design it so that it is separated into several segments of associated code. Only the segment being executed will be loaded if memory is low. If there is enough room, the entire program will remain in memory. The memory manager also provides for code-sharing where two or more copies of a program running at the same time share the same code but use separate data segments.

Debugging

A modified form of Microsoft's Symdeb symbolic debugger is supplied with Windows. You must run Symdeb on a different screen than Windows. If you have a CGA and a monochrome adapter, you're in good shape, since Symdeb will use the monochrome monitor. If you don't have two monitors, you must hook up a dumb terminal or another PC using terminal software to the COM1: serial port. As your program runs, Symdeb displays memory-allocation messages on the terminal or monochrome card when memory is allocated or moved. When you are in Symdeb, you can set breakpoints in your program, look at global variables, see the currently executing line of the program's source code, and examine the processor's registers. If you have a PC AT or compatible, you can use the System Request key to break out of Windows and get into the debugger at any time. If the computer hangs up, all you have to do is hit the System Request key to get into Symdeb and look at the offending line of code. If you use a PC XT, you'll have to simulate this by setting breakpoints where you suspect trouble.

Symdeb is much better than its predecessor, Debug, and can be useful, but it is far from what it should be. A debugger for Windows should run under Windows, not requiring a second screen, and it should use menu commands and dialog boxes to interactively debug instead of requiring cryptic two-letter commands. Microsoft's newer CodeView, a symbolic debugger included with Microsoft C version 4.0, cannot yet be used with Windows, although Microsoft has said that will change. A Windows version of CodeView would be useful, although another PC would probably be required solely for debugging.

Symdeb on a terminal is so awkward to use that we found it easier to use debugging messages like `starting function foo( )` or `count = %d` at key points in the program. We put these messages in a standard dialog box using the `MessageBox` function. Such messages are easy to code and give exactly the information that you want.

Documentation

The Windows development kit documentation totals about 1200 pages in three binders. One binder consists of the *Programmer's Utility Guide* and *Update to the Programmer's Reference*. The utility guide describes the syntax and usage of the utilities shown in table 1. The update explains features new to Windows version 1.03. The *Programmer's Reference* describes Windows functions, Windows data structures, and messages. Unfortunately, it is hard to see how the components work together.

What is conspicuously missing is a tutorial guide to Windows programming. The binder containing the *Programming Guide*, *Quick Reference*, and *Application Style Guide* explains one simple pro-

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System Requirements: MSDOS/PCDOS 2.0 or higher; 256K Memory; 1 Disk Drive or CP/M 2.2 or higher (Z80); 55K Memory; 1 Disk Drive (2 recommended)
Ctrace requires MIX C compiler & MSDOS/PCDOS (not available for CP/M).

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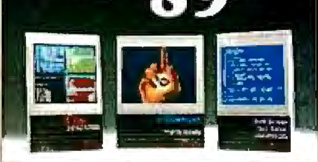

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gram, which prints "Hello, Windows." The example is useful, but one example is not enough. It took us quite a bit of reading and playing around with the sample programs on the disks before we started to understand Windows and how the applications work. A tutorial guide is desperately needed to explain the new concepts and caveats of Windows programming.

Once you get a feel for Windows programming, the documentation is efficient and easy to use. The manuals are organized logically with an ample number of examples, all in Microsoft C, and a good index.

Developers can obtain a license at no cost from Microsoft that allows the distribution of the Windows run-time system. This means that you can develop Windows applications without requiring the purchasers to own Windows. The catch is that the version distributed is specific to your application. The Windows package is needed to use more than one application at a time.

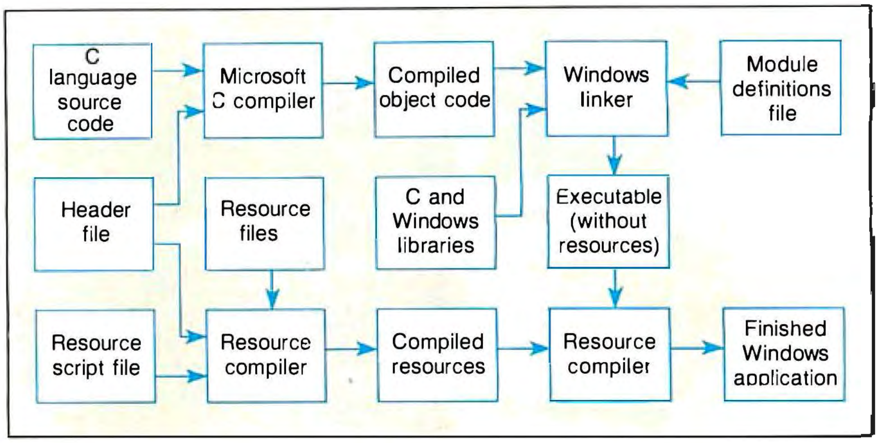

Figure 3: *The flow from source code to executable code required to build a Windows application. You can automate the process with the Make utility.*

Why Windows?

The Microsoft Windows Software Development Kit 1.03 is expensive, slow, and difficult to understand at first. Once the learning curve is conquered, though, you can enjoy the benefits of a consistent, intuitive, window-based user interface with pull-down menus, multitasking, and device independence. Also, Microsoft has stated that Windows applications will be easily ported to future operating systems.

Windows applications created with this kit require a hard disk with a PC XT compatible for mediocre performance and a PC AT for acceptable performance. The speed of Windows will become less of a problem as available hardware improves. Already companies are taking advantage of Windows's device independence by creating fast graphics boards for it. ■

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Smalltalk/V Release 1.2

Mat Davis

Smalltalk/V release 1.2 from Digitalk is an inexpensive object-oriented programming environment for the IBM PC and compatibles. At a cost of $99.95, Smalltalk/V implements the complete Smalltalk language, except for multitasking, as developed by researchers at the Xerox Palo Alto Research Center (PARC).

Smalltalk/V 1.2 is not copy-protected, and it follows in the tradition of Borland's Turbo Pascal in being a high-quality software package at an affordable price. However, Smalltalk/V requires 512K bytes of memory, two floppy disk drives or a hard disk, and a graphics adapter. Digitalk strongly recommends that you also have a Microsoft-compatible mouse, and an 8087 coprocessor is required for floating-point operations. The system supports the IBM Color Graphics Adapter in 640 by 200 mode, the Enhanced Graphics Adapter in 640 by 200 and 640 by 350 modes, the new Video Graphics Array's 640 by 480 mode, the AT&T PC 6300's and Toshiba T3100's 640 by 400 mode, the IBM 3270 PC's 720 by 350 mode, and the Hercules video boards. For this review, I used an IBM PC-compatible ITT XTRA with 640K bytes of RAM, a 20-megabyte hard disk, a Hercules graphics adapter, and a Microsoft Mouse.

Methods, Digitalk's original Smalltalk implementation that sold for $250, has been replaced by Smalltalk/V. The language supported by Smalltalk/V is identical to that used in Methods. In contrast to Methods, however, Smalltalk/V supports graphics, uses a mouse, and communications support is optional.

Features of Smalltalk/V

As with other object-oriented languages, a Smalltalk/V program consists of a collection of objects, such as integers, strings, programs, or airplanes, that perform computations by sending each other messages, such as `add`, `parse`, `run`, or `dive`. Smalltalk/V features all the characteristics of Smalltalk, including the ability of different objects to respond to the same message in different ways, support for inheritance, and encapsulation of objects. [Editor's note: *For more information on Smalltalk, see the August 1986 BYTE, which has a theme of Object-Oriented Languages.*]

The language implemented in Smalltalk/V is generally consistent with Smalltalk-80 from the Xerox PARC. However, while Smalltalk/V includes the basic classes of Smalltalk-80, such as *Stream* and *Collection*, some of the less basic classes, such as those used for windows, are incompatible. For example, while Smalltalk-80 considers a windowed application to consist of a model, several views, and several controllers, the same application in Smalltalk/V consists of a model, several panes, and several dispatchers. Even though this difference is primarily one of terminology, it means that programs using some of the more sophisticated classes may need considerable translation.

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Smalltalk/V has several special features, such as its use of virtual memory techniques that allow the normally huge amount of source code in Smalltalk (a minimum of around 600K bytes for Smalltalk/V) to work in a 512K-byte environment with a hard disk. While a 512K-byte system may not sound very small for a PC, many versions of Smalltalk require a minimum of a megabyte of RAM, and some require as much as 4 megabytes to achieve good performance. Thus, Smalltalk/V runs in a relatively cramped system.

Here's how Smalltalk/V's virtual memory works: When, during program development or when a program is running, the 512K bytes of memory fills up, Smalltalk/V spends a few moments moving some objects (those that do not "contain" other objects) to the hard disk before resuming normal operation. This does not happen with floppy disk-only systems, which, according to Digitalk, are too small and slow to support it. While the system slows down somewhat after this swap-out occurs, it brings objects back into memory as they are used, and, within a minute or so of your using the system, all the objects currently in use are brought back into memory. The system actually runs faster than before because more memory is available.

Smalltalk/V comes with many sample programs, one of which is Prolog/V. While the syntax of Prolog/V is not identical to the standard Clocksin and Mellish version, the differences are minor. Unfortunately, the only documentation provided for Prolog/V is in a file on one of the distribution disks.

Using and Modifying Smalltalk/V

Installing Smalltalk/V is quick and easy: you run a batch file that configures the system for either floppy or hard disks and your graphics adapter, and the system is ready to go. In addition to the Smalltalk interpreter and a small configuration file that gets modified by the installation process, Smalltalk/V comes with an image file, a sources file, and a change log.

The image file contains the current

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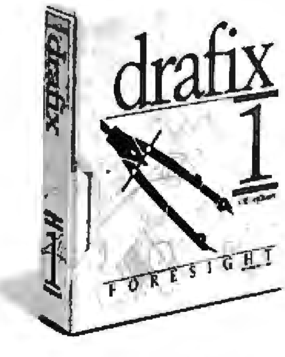
Revolution.



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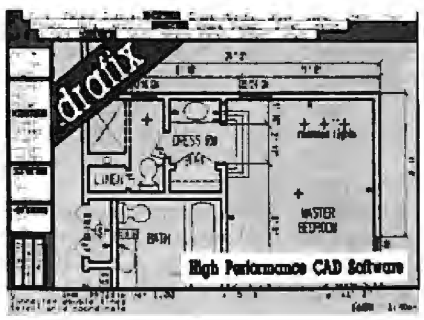

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image of the system. Unlike other languages, in which each program is isolated in its own file, a Smalltalk program is a collection of objects, classes, and methods, all of which become a part of the Smalltalk system after they are created. To save your work, you save an image of this system, which includes all the classes and objects in it. Since even the windows on the screen are objects, their size, position, and contents are also saved in the image. Note, however, that this creates some problems for developing applications with Smalltalk/V, since the program you are developing is actually part of the complete system. Distributing the application would mean distributing the entire system unless the other users already have Smalltalk/V.

The sources file contains, in a compressed format of about 300K bytes, the source code for the entire system except the compiler. Changes to the system take place as follows: When you add or change a method, the system writes the new code to the change log file, which is initially empty. Then the system updates its record of the code to reflect the new code's location in the change log. Thereafter, the new code supersedes any code that may be in the sources file. Since the information about the location of the new code is part of the image, you must always keep together a set consisting of the image file, sources file, and change log for them to remain consistent.

The change log also serves as a safety net; anytime an expression is evaluated, it is written to the change log. Since new objects can't be created unless some kind of expression is evaluated (even if the expression is as simple as `Dashboard Open`), the change log provides a complete record of the state of the system in the event of a crash. Even if you haven't saved the image for hours and a power failure or crash occurs, all the changes made during that time are in the change log, and you can recover them. Thus, the chances of losing work in a Smalltalk system are remote.

While the change log protects you against losing work, this protection is not often needed. Smalltalk/V is capable of handling the majority of programming errors by simply interrupting the errant program and allowing you to debug it interactively. The only exception to this arises when you make an incorrect modification to portions of the windowing code, and the system can't open its usual debugging window. In this severe case, Smalltalk/V encounters an error while trying to report an error and usually cannot recover. Fortunately, these cases are relatively rare, and you will generally have no problems modifying the system while it is running, a capability that became a tradition with Smalltalk-80, and it makes Smalltalk/V a robust system.

Smalltalk/V Windows

The standard Smalltalk/V system contains several types of windows. You can subdivide each window into smaller sections, called panes, and each window has two or more pop-up menus associated with it: a window menu for resizing, moving, or closing the window, and a pane menu that lists actions relating to each pane in the window. For example, the menu for a standard text-editing pane contains choices such as cut, copy, paste, and search.

The system-transcript window is Smalltalk/V's message window, and you cannot close it, although you can resize and move it. Class browsers provide the means for modifying and creating classes in Smalltalk/V. A class-browser window consists of five panes. The first two are used for selecting whether class methods (for messages sent to the class itself) or instance methods (for messages sent to individual instances of the class) are listed in the methods pane. The other three panes are for class, methods, and text. The class pane shows a list of all classes in the system. Choosing one of these classes causes a list of the methods defined in that class to appear in the method pane. The method pane's menu provides choices for adding and removing methods. You can also select a method, which causes the source code for the method to appear in the text pane, where you can edit and save it.

A workspace is a Smalltalk text editor that serves as a place for testing code, making notes, or performing calculations. To test programs or perform calculations, you can type any sequence of Smalltalk statements, select them with the mouse, and evaluate them using either the `Do it` or `Print it` choices from the pane menu. The `Do it` option evaluates the expression and discards the answer and is useful for expressions such as reading new code from a file where you do not need to see an answer from the system. The `Print it` command evaluates the selected expressions and displays the result in the workspace. Thus, you can do calculations by typing and selecting an expression, such as `7 * 3 + 4`, and then selecting `Print it`.

While the only code that is really a part of the system is that contained in the methods in the various classes, the contents of all the windows are saved along with the rest of the system, so code typed into a workspace can effectively become permanent.

Smalltalk/V provides debugging assistance through a series of interactive windows. When an error occurs, the system presents you with a walkback window that shows all the messages that have been sent but not yet answered. From this window, you can elect to either debug the problem or abandon the computation. If you choose to debug, a special debugging window appears. This window enables you to examine any of the variables in use, change their values, or change code. Once the error has been corrected, execution can be resumed.

Using Windows in Development

Class-hierarchy browsers, workspaces, and debuggers all play an important role in writing Smalltalk programs. For example, you use a class browser to create a new class by simply selecting its superclass and filling in a template for a class definition. You then use the class browser to write the methods for that class, and you can use a second or third browser to

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consult methods in other classes, which is a real convenience.

A workspace serves two purposes during program development: for defining any global variables that the application requires and for testing the partially completed application.

Finally, the debugger allows easy inspection of conditions when an error occurs. You can inspect objects, correct and recompile the code, and restart the program at the point where a selected message was sent. In fact, if you use an unimplemented menu choice in your application and get an error, you can use a class browser to add the missing method and then use the debugger to pick up execution where you left off. Thus, a menu may have a choice on it for which no method yet exists, but, as long as that choice is not used, no error occurs. This flexibility strongly encourages incremental testing and refinement.

Benchmarking Smalltalk/V

While Smalltalk systems work well for prototyping applications, they are not normally very useful for compute-bound programs. Smalltalk/V is no exception. It ran the BYTE Sieve benchmark in 31 seconds. This doesn't seem long when compared to the times achieved by BASIC, but most C compilers can run this same benchmark in under 15 seconds, and some can run it in under 5 seconds.

The speed difference is primarily due to the fact that compilers for production languages, such as C or Pascal, read your program once and then translate it into an equivalent machine language program. The interpreters for languages such as Smalltalk and BASIC, however, are constantly reading your program and carrying out its instructions. In the Smalltalk version of the Sieve benchmark, the main loop is interpreted over 8000 times, while the C version is compiled into machine language only once. [Editor's note: *The BENCH.OBJ source code for the benchmark tests is available on disk, in print, and on BIX. See the insert card prior to page 321 for details. Listings are also available on BYTEnet. See page 4.*]

On the other hand, Smalltalk/V is well-suited for certain types of numeric problems; with its support for virtually unlimited integers and arithmetic operations on fractions, overflow or round-off errors are rare.

For example, Smalltalk/V doesn't support floating-point numbers without a numeric coprocessor, so in the Calculation benchmark, I used the fractions $^{314159}/_{100000}$ and $^{271828}/_{100000}$ instead of 3.14159 and 2.71828. Since Smalltalk/V was performing its calculations using fractions, there were no errors, even after 5000 iterations. The test took 38 minutes and 44 seconds; certainly not quick, but neither the numerator nor denominator of either fraction fits in the 8086's 16-bit word. Since they do not fit, Smalltalk/V must expend considerably more effort to multiply, divide, and reduce these fractions than it would for integers.

A short program to calculate the first 50 factorials runs in just under 3 seconds and calculates each factorial exactly; the answer to 50 factorial is 65 digits long. In fact, while the recursive factorial routine provided by Digitalk causes a stack overflow while computing 1000 factorial, you can easily write an iterative version that will give you the full 2568-digit value.

The Disk Access in BASIC Write benchmark test (writing a 64K-byte sequential text file to a blank floppy disk) took 54 seconds, while the Read test (reading the same file) took 112 seconds. Compare this to the results for the ITT XTRA, whose tests were written in ITT's Advanced BASIC, with times of 33 seconds for the Write test and 32 seconds for the Read test. [Editor's note: *See the review "The ITT XTRA" by John D. Unger in the April 1985 BYTE.*]

Regardless of the results of such benchmarks, the real test of speed for an interactive language environment such as Smalltalk/V is actual use. Smalltalk/V usually takes only 3 to 4 seconds to recompile a typical method, and then you're ready to move on. This rapid response gives you the feeling that the system is quick, even on standard PCs.

Drawbacks of the System

While Smalltalk/V will run with 512K bytes of RAM and two floppy disks, the package responds much more quickly on a system with 640K bytes and a hard disk; the more memory you have, the less often the system has to swap objects in and out to disk, do garbage collection, and so on.

Smalltalk/V is also a considerable strain on a standard PC's processing power. The package includes a speed/space software option that speeds up the graphics at the expense of some available memory. After invoking it, the system will save windows that get covered up by other windows so that they do not have to be redrawn every time you access them. This saves time but eats up a lot of memory.

In addition, while Smalltalk/V works with a CGA, this adapter does not really provide enough resolution. The large pixel size results in crude characters and makes it awkward to make a class browser large enough to be useful. Using a Hercules-compatible graphics card, as I did, or an EGA in high-resolution mode eliminates these problems.

A Useful Manual

The documentation for Smalltalk/V is a rather impressive 514-page softbound handbook. The first half is an introduction to Smalltalk in general, and Smalltalk/V in particular, in the form of eight chapters of tutorials, with full source code for the examples on disk. While this book is probably not enough in itself to teach you all the ins and outs of object-oriented programming, it is a good start.

The second half of the book is an encyclopedia of the classes in the Smalltalk/V system. You'll probably use this section frequently, even well after you've become a Smalltalk hacker, due to the sheer number of classes and methods provided.

Smalltalk/V Options and Goodies

Options available for Smalltalk/V include an EGA/VGA color-extension kit and a communications package. This communications package comes with full source code for the assembly language communication primitives and sample Smalltalk classes, such as a simple terminal-window class and a Unix browser class. Omissions from the terminal windows include protocol transfers and emulation of the Digital VT-100 or any similar terminal. If Digitalk doesn't provide transfers and terminal emulation relatively soon, it's a good bet that someone else will.

The browser for use with Unix systems lets you, after logging on, transfer files to or from the Unix system (in text mode only), change directories, or run programs. Again, since full source code is provided, you can fix any minor problems or expand the browser in any way you desire.

Digitalk has also announced a Goodies extension kit that has support for sound and multitasking, but it was not available at the time of this review.

Good Things in a Smalltalk Package

Smalltalk/V is an unusually robust and complete system. Even when running on a standard PC, it rivals other Smalltalk systems that require more powerful computers, more memory, and more disk space. The supplied source code provides many examples of Smalltalk programming, as well as virtually unlimited potential for customization.

While Smalltalk/V may not be suitable for producing production systems due to speed and space requirements, the package is well worth its $99.95 price tag as an introduction to Smalltalk and object-oriented programming. ■

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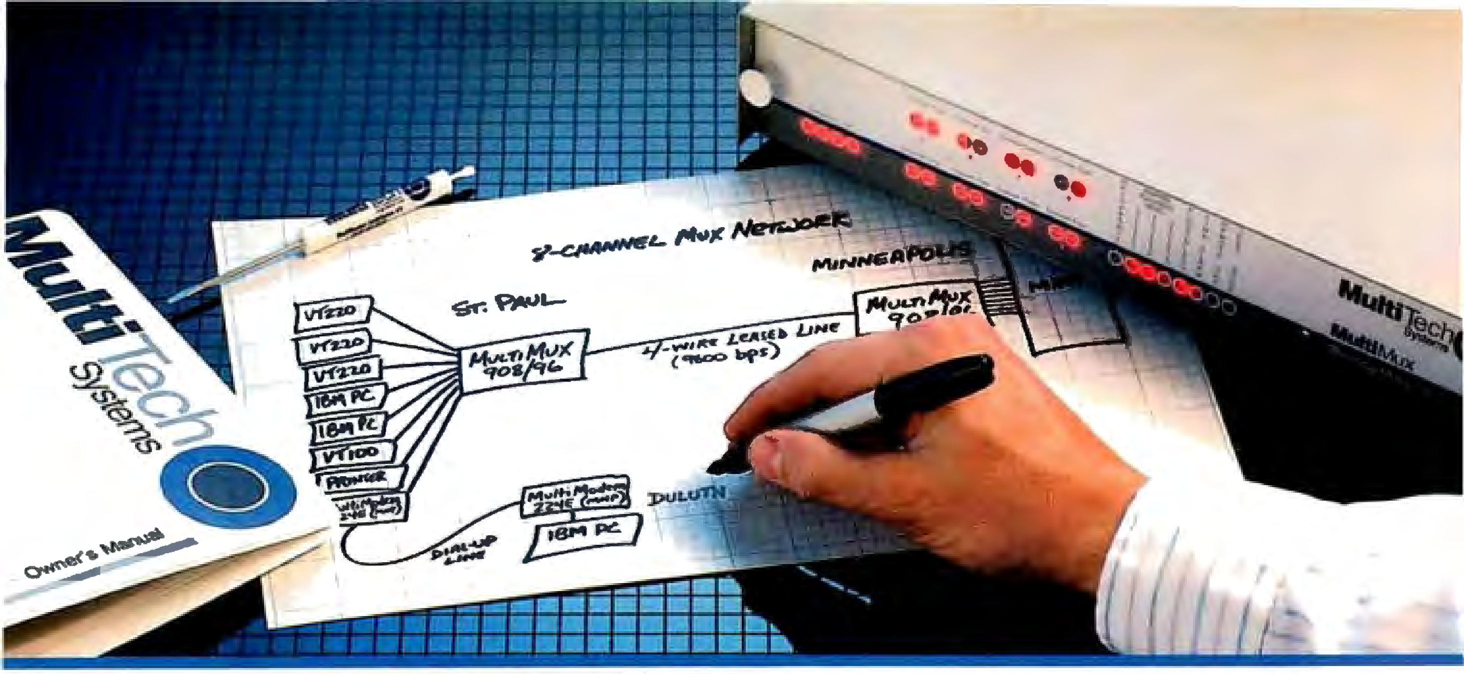

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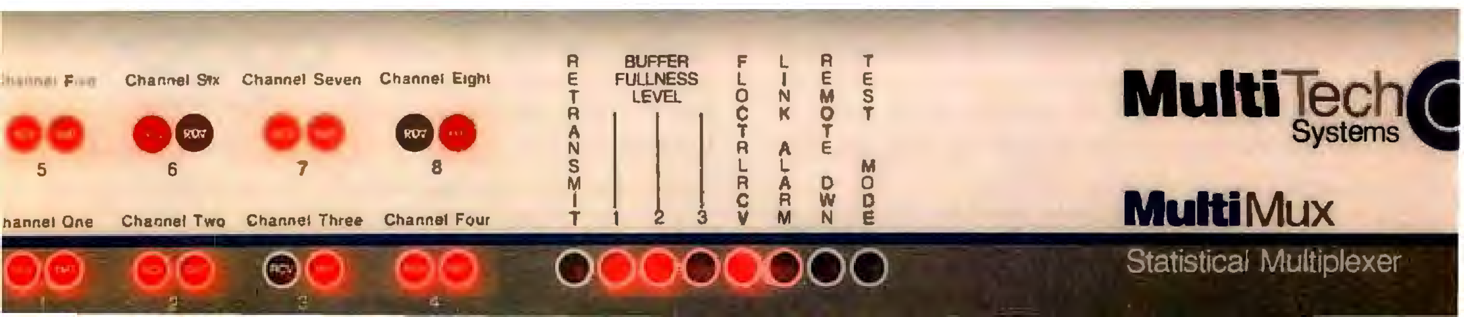

Acquaint

Ernest R. Tello

A frame-based knowledge-development system for the IBM PC

Lithp Systems' Acquaint version 2.4F is an expert-system tool, one of the first true frame-based systems for the IBM PC that I have seen. Frame-based systems use object-oriented representations for both knowledge and control. Acquaint is written in Soft Warehouse's muLISP. Within the artificial intelligence community, choosing LISP as a delivery environment usually means a significant loss of performance; however, this package is an exception.

Acquaint requires an IBM PC, XT, AT, or compatible with a minimum of 256K bytes of RAM running MS-DOS 2.0 or higher with one floppy disk drive. I tested it on an IBM PC with 512K bytes of RAM running MS-DOS 3.0 with one floppy disk drive and a Bernoulli box.

The Acquaint system is comprised of three main programs: QAINT.EXE, the user environment, QEDIT.EXE, a text editor for creating the knowledge-base file, and KAINT.EXE, the development environment. Three main windows are always present when QAINT runs: STATUS, INFO, and BROWSE. Acquaint also has a multiwindow drop-down menu environment for both users and developers. Developers can build stand-alone expert-system applications without paying an additional license fee, and the users need not purchase Acquaint.

The Heart of the System

Acquaint system architecture is built on four basic types of knowledge structure: concepts, rules, contexts, and forms. The concept structure provides the basis for classes of attributes that have limited property inheritance capabilities. The DefConcept construct uses a basic LISP-like frame template to declare concepts (see listing 1). Some of these options are self-explanatory: The PROMPT slot requests what text you want Acquaint to use to request the value of the concept, the FACT slot is for explanatory text to be used in displays needed with the BROWSE facility, and the COMMENT slot can contain any additional explanation.

Other concepts require more explanation. In the EXPECT slot, you specify the concept's data type and legal values. The simplest option is Y/N, a yes or no question that stores a certainty factor as an answer. The GROUP option specifies that the concept being defined is a collection of related subconcepts. You can specify subconcepts by listing them after GROUP, or you can include them in any rule that specifies this concept group; that is, you put GROUP in the EXPECT slot and then specify the subconcepts later in the rules when you write them.

For a numerical concept, you can specify maximum and minimum values with the RANGE option or a list of permissible values with the VALUE option. For example, you could define the concept Workday in the following way:

```
(Defconcept Workday
  EXPECT:
  Monday
  Tuesday
  Wednesday
  Thursday
  Friday)
```

Using the plural VALUES instead of VALUE lets you select more than one value from the list. Other options for the EXPECT slot include CONVERT and CONVCS, which associate a word with a value.

The DO slot uses available functions and operators to perform a calculation or an operation on various input arguments to determine the value of the concept. For example, you could use DO: (LENGTH * WIDTH] to define the concept RECTANGLE-AREA. The VAL slot lets you specify a constant concept, for example, the concept MONTHS-IN-YEAR is a constant and could be defined as (VAL 12]. The FUN slot lets you define new functions that you can call by name either in the DO slot or in the rules. FORMAT lets you format the screen into fields, and CLASS makes a true class hierarchy available so that all properties and formulas can be inherited. DEFAULT holds default values for concepts in case the system can't find a value.

Finally, the options for the PROP slot include ASK (the default), ASKFIRST, ASKNOT, CALC, and STORE. If you omit the PROP slot or specify the default, Acquaint tries to look up the value or infer it from the knowledge base. It asks you for the value only if this process fails. ASKFIRST tells the system to ask you for the value first. Some ASKFIRST concepts at the beginning of a program save time because they give the knowledge base some facts to process. ASKNOT is usually used for concepts that are conclusions the system must reach. CALC and STORE are opposites: CALC asks that Acquaint calculate a defined formula each time it is requested; STORE asks that it be calculated once and then stored so all subsequent requests will return the same value.

Writing the Rules

Once you have declared the concepts and constants, you can begin writing rules. DefRule uses a format similar to DefConcept's:

(DefRule *rule name*
  IF
  PROP *option*
  premise
  THEN *conclusion*
  ELSE *conclusion*)

continued

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Listing 1: *The LISP-like frame template that Acquaint uses to declare concepts.*

```
(DefConcept concept name
 PROMPT: question
 FACT: description of the fact
 COMMENT: further explanation
 EXPECT: type of answer
 DO: calculations to be made
 VAL: value to assign as constant
 FUN: LISP function definition
 CLASS: place of concept in hierarchy
 FORMAT: subset of Common LISP formatting
 DEFAULT: default value of concept
 PROP: properties of the concept)
```

In Acquaint, an entire rule must be of a logical type defined by one of the logical operators. The type of logical operator tells the system how to combine the premises and their certainty factors. The options you can use with PROP include the familiar logic operators, $AND, $OR, $NOT, $NAND, and $NOR, and two others, $OR* and $AND*, which let you declare collection rules.

Ordinarily, the evaluation of a rule ceases once the system knows whether it is valid or invalid. For example, with an $OR rule, if the first premise is true, you don't need to check the rest. Similarly, if the first premise of an $AND rule is false, you don't need to evaluate the rest. However, if you want to find out as much as you can as soon as possible, you may want to use collection rules. The $OR* rule always seeks the values of all its premises, even after finding one or more to be true. Similarly, the $AND* rule evaluates all premises even after one is found to be false.

A Tree Structure

The context, Acquaint's knowledge structure, differentiates it from many of the other expert-system shells currently available. The context determines how to group sets of rules together for processing. It is a kind of "metarule" because it tells the system which rules to consider. However, the context itself also has conditions that must be processed before Acquaint can transfer control to another context. To define a context, you use the following format:

```
(DefCont name
  IN:name, name
  COMMENT: text
  PROP: properties
  IF: if clause
  DO: do clause
  FORM: forms)
```

The IN slot is where you declare the context's dependencies on other contexts. Only one context, the one occupying the root node of the hierarchy, has no IN slot. Subcontexts must all mention either the root context or one of its child nodes in their IN slots. The result is a hierarchical tree structure of rule sets, each defined by a context.

Contexts can have properties specified in a PROP slot. Each member of a concept group with the same name as that context will inherit those properties. For example, if the PROP slot of the INVESTIGATE context specifies ASKNOT, and a concept group called INVESTIGATE also exists, then all concepts in the concept group also inherit the ASKNOT property.

The IF slot follows the same syntax that it does with rules; it allows the context to act as a "super rule," or group rule. If the rules in a set contain one or more common premises, you can write these rules with only the premises unique to each; the IF slot will contain the common premises of the context that groups them together.

The DO slot also follows the same syntax that it does with rules. In addition, it can contain the $FLUSH option, which sets the value of a class of concepts to zero so that Acquaint will not pursue them, or it can contain the $DO-CONT option, which lets you declare the sequence of contexts you want the system to consider. This sequence must end with the END context, or processing will not terminate.

Rapid Input

Forms are input templates on which you enter information directly into Acquaint rather than in response to questions. Forms are relatively easy to declare in a knowledge base, but you must be careful to reserve the fields properly. You declare them in the following way:

```
(DefForm var-1
  var-2
  ...
  var-n)
```

You list the variables in the order you want them to appear on the input form. If a form is attached to a context in the context declaration, then the form automatically comes up when that context fires, or executes. If no form is attached to the context, you can call it up voluntarily via the INPUT option on the QAINT user environment's DIALOG menu. If you plan to use unattached forms, however, the user needs to know that the form is available, as well as how, when, and why to use it. You also need to create special instructions to explain the unattached forms available, or the user may miss them entirely.

Acquaint combines the best features of the consultation and the mathematical problem-solver paradigms with the input forms facility. You can get a complete consultation environment with as much instruction and help information as you wish, but you can still use a template form to supply your input rapidly when you need to.

How Acquaint Reasons

Acquaint is one of the first IBM PC-based systems to offer both contextual rule sets and forward and backward chaining. Contextual rule sets can partition an expert system's knowledge into distinct sets of rules so that, at any given time, the system needs to search only a limited set of rules rather than all of them. Contextual rule sets can make an enormous difference in the performance efficiency of a large knowledge-system application.

Acquaint combines both forward and backward chaining with an inference-control algorithm. This algorithm is one of the most important criteria that distinguish one expert-system shell from another. An inference engine controls how reasoning begins, how it proceeds, and how it concludes. Generally, Acquaint's inference engine combines both backward and forward chaining in a consultation, but you can control the degree to which a system forward-chains.

In Acquaint, you can determine a session's beginning point in two ways: with forms and formulas or with collection rules. If you use forms to input information, the system will usually activate forward chaining. This works properly only if no collection rules exist in the knowledge base. Generally, if they do exist, they are supplied as the first rules in the system and reference many other rule groups. The evaluation of a collection rule is not finished until all the rule groups that it calls have been processed. Therefore, if you wish, you can temporarily bypass any forward chaining and

continued

make the system evaluate all the specified rules.

If you don't use forms to enter information at the start of a session, the reasoning process in Acquaint will begin with backward chaining by default, because forward chaining needs facts to work on, and the system may not have any yet. The backward chainer is usually initiated by an ASKNOT rule or an ASKFIRST rule. First, it takes the conclusion of a rule as a hypothesis to be proven; then it chains to the premises of the rule, to other rules that can prove the premises, and so on, until it proves the rule. During this process, Acquaint may ask you for facts it will use to try to prove rules when it begins forward-chaining. The forward chainer itself doesn't ask you any questions; it uses only internal means to prove as much as it can by all the facts it has. When it exhausts all its possibilities, it returns control to the backward chainer to examine a new hypothesis.

Unprocessed hypotheses are selected from the AGENDA, the list of rules, in order of their importance. To determine this order, or priority, Acquaint uses an evaluation function that estimates the probability that a given rule will have a positive outcome. The criteria used in making this estimate are the number of premises of a rule that are known, the degree of certainty by which the premises are known, and the amount of evidence that is still missing.

QAINT: For Users

On the main menu, START begins executing the knowledge system that is loaded. EXPLAIN, DIALOG, and INFO are the three major modes of the user-interface program: EXPLAIN interprets questions, rules, and conclusions; DIALOG conducts consultation sessions; and INFO lets you BROWSE through various parts of the knowledge system.

On the EXPLAIN menu, the WHY option lets you ask Acquaint why it asked a particular question. The system responds with the reasoning chain that led to the question, which you can then BROWSE through if you wish. When the system has reached a conclusion, you can use the HOW option to see the reasoning involved. (You can also use it following the INFO option on the main menu.) If Acquaint reaches a conclusion by a series of rules, it will display the names of those rules in the BROWSE menu, and you can select them for display one at a time. The TRACE option lets you inspect all the rules in a given context or all available rules; you can select them in the same way from the BROWSE menu. The AGENDA option lets you see the list of rules Acquaint cur-

continued

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Acquaint 2.4F

Type
Frame-based knowledge-development system and expert-system tool

Company
Lithp Systems BV
P.O. Box 65
1120 AB
Landsmeer
The Netherlands
011-31-2908-4623

Format
Two 5¼-inch floppy disks

Computer
IBM PC, XT, AT, or compatible with a minimum of 256K bytes of RAM running MS-DOS 2.0 or higher with one floppy disk drive

Language
muLISP

Documentation
Acquaint User's Manual

Price
$4000

rently intends to try, in the order of their estimated importance. The QUESTIONS option shows the recorded results of all questions asked of the user so far, and the QUIT option returns you to the main menu.

The BROWSE window shows all the INFO items you can select. Most are self-explanatory. The INFO RULES option asks you for a search pattern. You can press Return if you want to see a list of all the rules in the BROWSE window. A similar approach is used for concepts and contexts. If at any point during a consultation you decide you want to see what is currently known, you can select the INFO CONCEPT option and look at a given concept or concept group to see what the system knows about it. If you select INFO CONCEPT, QAINT provides you with a list of all the concepts from which you can choose.

KAINT: For Developers

The application-development environment consists of the KAINT.EXE program and an additional utility program, COMTOEXE, which converts .COM files to .EXE files. The menu of options is located in the upper right corner of the screen, as it is in QAINT. KAINT's RESTORE option lets you compile the expert system from a text file into LISP code that QAINT can execute. The DUMP option writes an expert system to disk after you have compiled it, and the ERASE option initializes the KAINT program so that you can load another knowledge system. INFO enters the BROWSE facility to inspect various elements in the knowledge base. Acquaint also includes a text editor, QEDIT.EXE, to create the knowledge-base file.

Acquaint has an interface to muLISP that lets you use the language's standard functions and call them from within rules. For example, `DefConcept RESMAN DO: ((BAND1 + BAND2) * EXPT (BAND3 10)]` is a line from an Acquaint application that lets you enter the color bands of a resistor and find out its resistance and tolerance.

EXPT is a muLISP function that calculates an exponential expression, in this case, $BAND3^{10}$. Such functions significantly expand the capabilities of Acquaint. Writing the functions that take advantage of this interface is not necessarily a trivial task, however; you will need to use the documentation for both muLISP and Acquaint internals.

What Acquaint Won't Do

Earlier versions of Acquaint were unable to create iterative loops based on user input. Some expert systems need this ability so the user can fill in information in a list of indefinite size. For example, let's say you are building a knowledge system to advise a company's managers about their organization. You, as the knowledge engineer, may have no idea how many departments there are or how many people are in each department, but you want to ask the same set of questions of each department.

In a list-processing language like LISP, with each iteration of the list of questions you can append the answers to another list of indefinite size. With version 2.4F of Acquaint, you can use the interface to muLISP to write these kinds of functions, but it may not be easy. In particular, you will need to know Acquaint's windowing environment so you can ask the user questions and receive answers. Otherwise, your functions won't know how to print their questions on the screen.

Multiple-choice questions are also limited. You can ask the kind in which the response is the reentry of the full item listed, but Acquaint doesn't support answering with the number of your choice, at least not as a built-in feature. I would like to see concepts that have lists as

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values as a built-in feature. I would also like to see concept functions include list-processing functions to manipulate these lists in various ways, based on user inputs.

An Effective Tool

Acquaint's frame-based knowledge-development system has a simple hierarchical class structure that allows multiple but limited property inheritance by subclasses. One unique characteristic is its forms feature, which allows experienced users of expert-system applications to enter all their answers on a template at one time, rather than when the system asks for them.

Acquaint is one of the first IBM PC expert-system tools to use a frame-based approach to knowledge processing, allowing it to partition the knowledge base into structured rule sets that constitute distinct search spaces. Since you can keep the search within the bounds that are set by context frames, you can develop potentially huge, structured knowledge systems without suffering from increasing inefficiencies.

Acquaint's three most attractive qualities are that it has surprisingly good speed performance for an interpreted LISP application (a subjective but not uneducated point of view); it can build large, efficient, partitioned knowledge bases; and you can configure each expert-system application with its own dedicated run-time package so the application's users don't have to pay a license fee to Lithp Systems for Acquaint. ■

Zoomracks II

Tyler Sperry

Zoomracks from Quickview Systems is a text-database manager distinguished by a unique visual interface. Unlike traditional database programs with numeric capabilities, Zoomracks is designed to organize character-based records of variable length, such as correspondence or research notes. Though basically a note organizer, the program can also handle related tasks, like simple word processing and calculations.

The program is currently available in two versions, Zoomracks I ($79.95) and Zoomracks II ($119.95). Zoomracks I lacks two capabilities of Zoomracks II: the ability to handle more than one printing format and the ability to save macros in disk files. Both versions of the program are available for the Atari ST series and the IBM PC and compatibles. I reviewed Zoomracks II on an Atari 520ST equipped with 512K bytes of RAM, two floppy disk drives, a color monitor, and a mouse. The package will run on a 520ST or 1040ST with a minimum of 512K bytes of RAM and a single floppy disk drive, and you can use it without a mouse.

The Zoomracks View

The feature that most clearly distinguishes Zoomracks from similar programs is its user interface. The program was designed by Paul Heckel, author of *The Elements of Friendly Software Design* (Warner Books, 1984), and Zoomracks reflects his concerns about a friendly interface.

Zoomracks' file-handling interface uses the metaphor of time cards in a vertical rack. Cards stored this way typically reveal the top line of information on each card, which permits quick visual searches. The time-card metaphor is faithfully implemented in Zoomracks: Each database file is displayed as a rack of cards, with each card, or record, displaying the line of text contained in the first field of that record. This display lets you quickly scan a screen's worth of cards in a glance.

While not traditional, the Zoomracks display is easy to use in organizing material. Cards can contain up to 27 fields, and each field can hold up to 250 lines of text, with up to 80 characters per line. By displaying just the first line of information in a card, you can hide information in a manner similar to an outline processor.

Zoomracks lets you open and display up to nine files at once (assuming you have sufficient memory to hold them all). Normally, you wouldn't expect to view more than one or two files at a time, since a normal screen is only 80 characters wide. This is where a Zoomracks feature called SmartZooms comes in handy: By displaying text in a compressed mode (i.e., with some vowels and other characters deleted), it's possible to display several files at the same time.

Using the cursor keys or a mouse, you can quickly select and display individual cards or move between different files. Options are shown by a series of menus displayed at the bottom of the screen. To access the menus and submenus, you can use the mouse, Alt-key commands, or single-key commands. Once you've selected a menu, you use single-key commands to choose options. Virtually every menu uses the same key for entry and exit. Pressing the *Q* key once, for example, takes you to the menu for quitting the program; pressing *Q* again takes you out of the menu. An accidental keystroke merely toggles you in and out of a menu. The most common actions, like changing the view of a card, are also available via function keys.

Despite the metaphor of time cards, the menus, and the mouse, Zoomracks' interface is not for everyone. It generates a rather quick polarity response: Some people take to it immediately, while others find it awkward to manipulate. Beginners will find the menu system reassuring and simple to use, but more experienced users who want to bypass the menus may find the command-structure shifts between function-key and Alt-key combinations cumbersome. Also, when you enter the program's editor, the traditional WordStar Control-key assignments are available when you edit a field; you cannot use these commands, however, when viewing a field. Finally, some of the commands—Alt-E for entering the "extra" submenu, for example—are nonintuitive. The upshot is that with all these different types of commands, it can be difficult to remember which ones pertain to the part of the program in which you're currently working.

A Standard Editor

Compared to the program's interface, Zoomracks' editor is more standard. Editing a card's field is easy: You simply select the card and field you want to edit and press a function key. In the editing mode, a number of commands follow the familiar WordStar Control-key conventions. The editor supports standard functions, such as searching and paragraph formatting, as well as extras, like the ability to insert the current date and time.

The editor is supplemented by print formatting with output forms. Each file has an associated output form that contains information such as headers, footers, and how each field will be printed, such as centered or flush-left. You change output forms, which consist of a series of formatting commands and field names, with the editor.

The combination of text editor and output forms is quite effective for applica-

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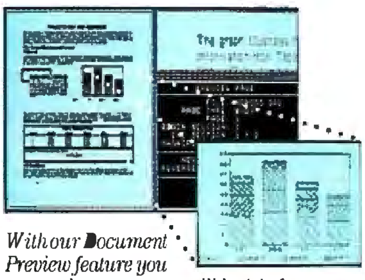

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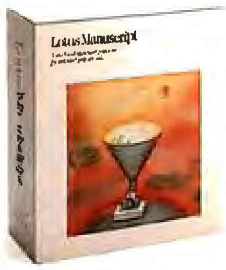

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tions like mailing lists and printing three-up labels. It's also adequate for simple correspondence. However, Zoomracks cannot be seriously considered as a word processor. Missing features include printer-configuration options, underlining, boldfacing, italics, and other character-formatting options.

Design Quirks

You might expect the mouse to be heavily used in Zoomracks, a product designed to be the essence of user-friendly software, but this is not the case. In Zoomracks, mouse support is limited. You can use the mouse to select cards and racks to view and select menu items, but that's about it. You can also use the mouse to scroll through a rack of cards and "zoom" a card to fill the screen, but you have to go back to the cursor keys to scroll through the contents of the card you just pulled up. The mouse is not implemented in the program's editor; according to Quickview Systems, the editor will make use of the mouse in the next version of Zoomracks, planned for release later this year.

In addition, you must be careful to position the mouse precisely when using it to examine the Zoomracks file directory; placing the mouse inaccurately when activating the directory results in the creation of empty files. Also, if you're tempted to turn off the menu at the bottom of the screen, don't do it while using the mouse. The menu is simply rendered invisible, not disabled, and attempts at selecting a card at the bottom of the screen can result in unexpected menu choices.

Another problem concerns file handling. Zoomracks' user's manual claims the program can display pictures stored in the DEGAS format. Unfortunately, Zoomracks doesn't use the Atari's GEM interface or Alert boxes to select pictures for viewing. To view a DEGAS file, you type the file's name into a blank field and press a function key.

You won't run into trouble with this procedure if you've written down the name of the file you want to view, but if you haven't jotted down the filename, you may run into problems. Since you must enter the exact filename to view the file and the Zoomracks directory displays only those files that have the .ZRX extension, you're effectively forced out of the program to find out what's on your disk. In addition to making importing files a nuisance, Zoomracks' file-handling makes folder use awkward. You can open folders only from the Atari's Desktop, not from within the program.

When I tried to load a sample DEGAS file, Zoomracks refused, claiming that displaying a high-resolution picture requires a monochrome monitor, which I didn't have installed. However, the file that Zoomracks rejected was a medium-resolution color picture that another program was able to display without difficulty.

Speed and Memory

For small applications that you normally associate with a card-file program, Zoomracks is certainly fast enough. I performed benchmark tests using a dummy database that consisted of 1000 records, numbered 1000 through 1999 in the first field. The other three fields contained dummy text strings of 32 characters each. The result of sorting the first field from reverse order was 36.3 seconds. Searching for the last record took 7.2 seconds.

You should note that Zoomracks is designed to handle ASCII text, and sorting is limited to ascending order. Sorts performed on numeric fields will thus lead to interesting results (e.g., 1, 10, 2, 3, ...) unless you manually pad the fields with leading zeroes.

The speed of Zoomracks in the benchmarks is largely due to the program's use of RAM-based operations instead of disk accesses. Thus, while it took only 7 seconds to search through the benchmark file, it took 55 seconds to load the file from the floppy disk—the program also sorts the file when loading it.

The speed gained through the program's RAM-based operations must be weighed against the RAM requirements for your application. Zoomracks cannot handle any file or collection of files larger than the amount of available RAM.

Moreover, this brings up other memory considerations. Experienced Forth programmers accustomed to having the functions of an editor, an assembler, and a compiler in 50K bytes or so will be surprised to find that Zoomracks, written in Forth and assembly language, weighs in at 227K bytes. When you add the RAM needed for the video display, the TOS operating system, and any desk accessories you've installed, the half-megabyte of memory on an Atari 520ST suddenly seems cramped. For example, I could not load the 114K-byte benchmark file until I had stripped my boot disk of several desk accessories.

Applications requiring less than 100K bytes of file storage should pose no problems. If your database is going to exceed 100,000 characters, however, it would be wise to consider dividing the database into different files or switching to an Atari 1040ST with a full megabyte of RAM.

Macros, Math, and Manuals

Zoomracks includes a macro capability that enables you to record a sequence of commands and link it to a single key. To replay the commands, you press a function key and then the assigned key. This capability goes a long way toward easing some of the awkwardness of the user interface. Instead of moving through a maze of menus to create and date-stamp a blank form, for example, you can assign the whole procedure to a single macro. You are limited, however, to 27 macros.

Zoomracks also includes some mathematical capabilities, which are limited to the basic arithmetic functions. These functions are certainly adequate to handle everyday applications like invoices and such, but not for complex number crunching. The program cannot, for example, automatically sum columns, although you can program a macro to perform this function.

The Zoomracks user's manual is tutorial in nature, generally well written, and indexed. The package also includes a

continued

Zoomracks II

Type
Text-database manager

Company
Quickview Systems
146 Main St., Suite 404
Los Altos, CA 94022
(415) 965-0327

Format
One 3½-inch floppy disk; not copy-protected

Computer
Atari 520ST or 1040ST with 512K bytes of RAM and one floppy disk drive; mouse supported, but not required

Language
Forth; assembly language

Options
$19.95 each for Business and other Starter Kits

Documentation
200-page user's manual; function-key template; command-reference card

Price
$119.95; Zoomracks I costs $79.95; an upgrade from the previous release of Zoomracks (the Premier version) to Zoomracks I is $14.95; to Zoomracks II, $49.95; versions are also available for the IBM PC and compatibles for $119.95.

Zoomracks is fast enough for small applications because of its RAM-based operations. But you'll have to weigh its speed against its memory requirements.

function-key template, a double-sided command-reference card, and an on-line help file, but no reference manual.

Quickview Systems provides good user support, especially considering that it's a small company. There is no toll-free number for assistance, and it might take a couple of hours to get a return call if no one is immediately available. The chances are excellent, however, that when you talk with people at the company, they will be knowledgeable and helpful.

As additional support, Quickview Systems sells Starter Kits for Zoomracks. These kits, which sell for $19.95, contain a set of templates and macros for various applications. The Business Starter Kit, for example, contains templates for invoicing, phone logs, and so on. Sales, mailing list, accounting, and other kits are also available.

Best for Simple Filing

The final judgment on Zoomracks will depend on your planned application. If you're intrigued by the card-rack metaphor and have modest database requirements, Zoomracks is certainly worth investigating. There are some nonintuitive commands and bugs in the current version of the program, but, despite all that, it still gives you a useful tool for organizing and manipulating text data.

For demanding applications, however, none of the program's functions—text editing, database handling, and calculating—are sufficiently strong to compete head-to-head with a dedicated application program. Few word-processing programs, for example, are unable to handle simple underlining. As a working writer, I'd consider Zoomracks worthwhile for notes and simple correspondence only. For larger projects, such as this review, I'm quite happy to stick with my IBM PC compatible and a standard word processor. ■

Tyler Sperry (P.O. Box 7189, Redwood City, CA 94063) is a freelance author.

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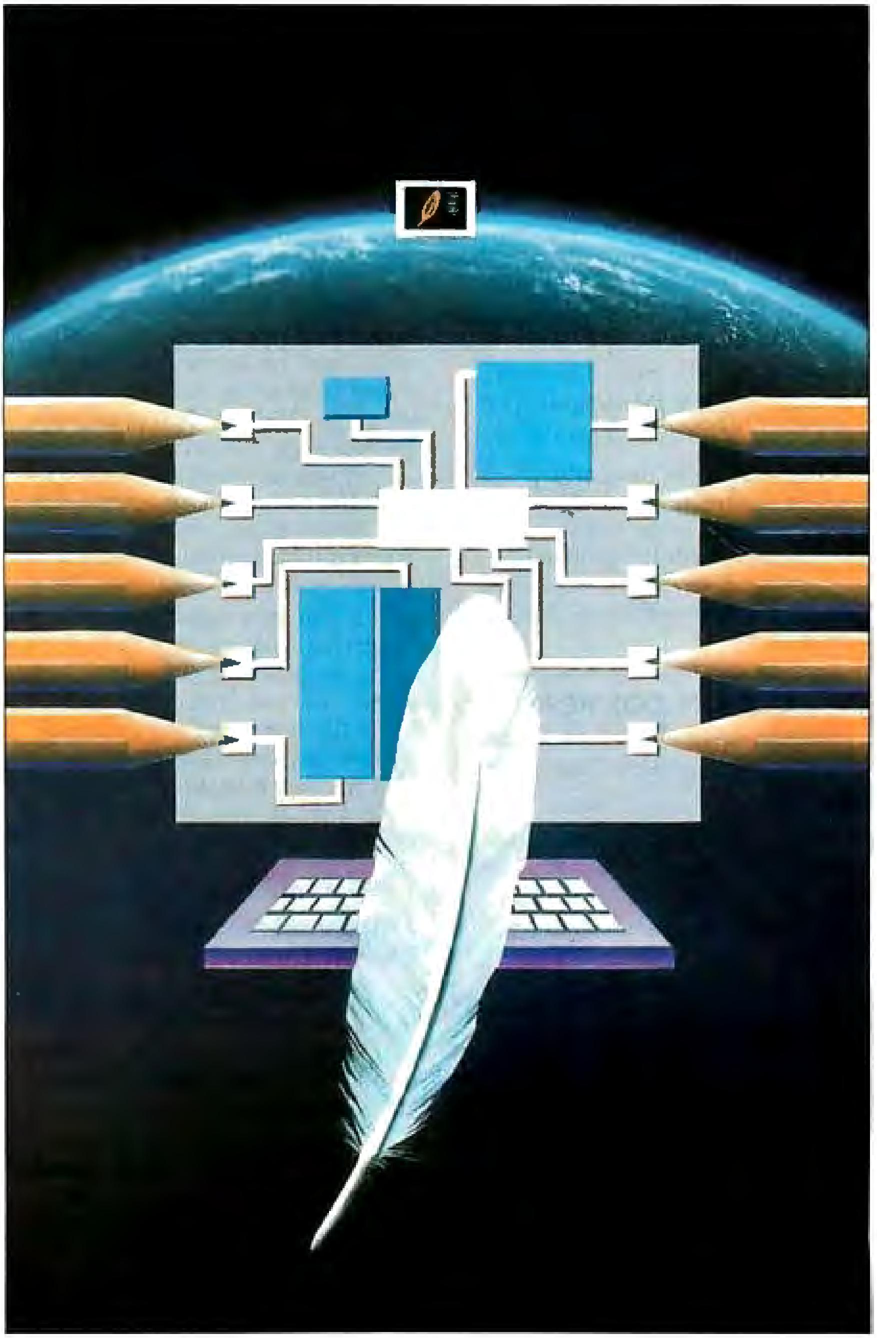

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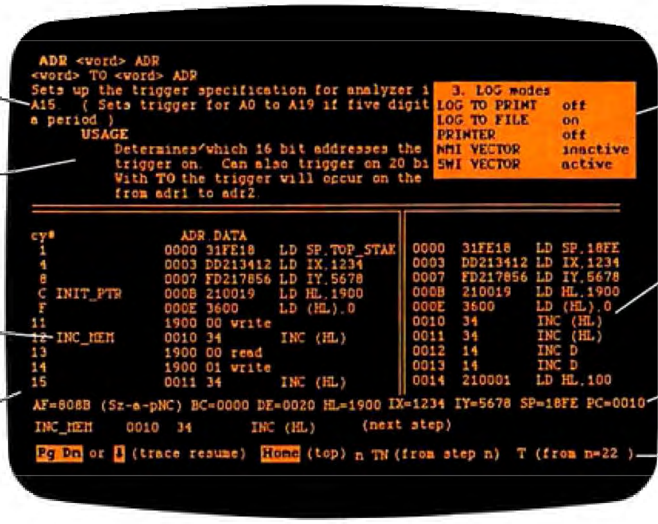

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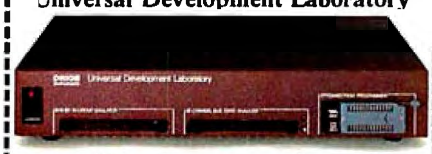

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Puttering with Yin and Yang

Jerry Pournelle

A computerized oracle advises Jerry to do some random reporting

I think they're trying to kill me: they've got me on the road more than I'm at home. I got back from the Seybold Conference on Desktop Communications with barely enough time to write last month's column, then I was off to the American Association for the Advancement of Science meeting in Chicago. After that, I managed a week with Larry Niven working on *The Moat Around Murcheson's Eye*, our sequel to *The Mote in God's Eye*; then off to Boston and the tenth anniversary meeting of the Boston Computer Society, and a drive up to BYTE headquarters in Peterborough. Back home just in time to go to Sacramento for the fourth annual meeting of Contact, the group that brings together hackers, anthropologists, and science fiction writers.

I returned Sunday night, and on Monday went to AppleWorld, where they announced the (fantastic!) Mac II and Mac SE; and Monday evening I headed to Seattle for the second annual conference on CD-ROMs.

Of course, much good will come of all this travel. Eventually I'll have a lot to report, but for now it has cut severely into my tinkering time at Chaos Manor. So: shall I try to extract some serious conclusions from the AAAS meeting and CD-ROM conference? Or just putter around, grabbing things at random, and reporting what I think?

The Oracle

There's one way to find out. I'll consult the *I Ching* on Zelda, the Zenith Z-248 AT clone.

I've written about this before, but for those who don't remember, the *I Ching* or *Book of Changes* is an ancient Chinese oracle. The Baen Software's program called Electric Dragon offers the Richard Wilhelm (Princeton University Press) translation, considered one of the best.

The *I Ching* is not a mere fortune-telling device, although it's used for divination. You can think of it as a mental exercise. One Chinese writer said, "Common minds use *I Ching* to predict the future. Sages use it to understand the present." *I Ching* is supposed to explain what is happening to you and recommend what the superior person should do. Carl Jung, among other intellectuals, took it seriously, and I'm always amazed at how appropriate to the question asked the *I Ching* meditations seem to be.

You needn't believe in the *I Ching* to use it. It's better than flipping coins, because while it certainly gives answers, you have to give some thought to what the oracle tells you.

So. Let's consult it about this column.

Hexagrams

The *I Ching* consists of 64 figures called hexagrams; each has six lines. A line can be yin (yielding, or broken) or yang (firm, unbroken), and each can be fixed or moving. A line moves to become its opposite. You consult the oracle by generating a hexagram one line at a time; if you get one or more moving lines, in effect you have generated two hexagrams, since one will become the other.

Since each line has two characteristics (yin/yang, fixed/moving), we need two random but not equal probability numbers to generate each line. The classical method involves yarrow stalks. There is a simple method of tossing three coins (all heads is moving yang, two heads is fixed yang, etc.), but the Electric Dragon program has the computer generate the hexagram one line at a time and displays it on-screen with the interpretations.

I went through the procedure and got the fourth hexagram, "Youthful Folly." The interpretation is, "Youthful Folly has success. It is not I who seek the young fool; The young fool seeks me. At the first oracle I inform him. If he asks two or three times, it is an importunity. If he importunes, I give him no information."

There were no moving lines. This hexagram doesn't invite you to repeat the question. It seems a clear enough answer to me. It's short-shrift time at Chaos Manor.

Truly Portable

One consequence of traveling about the country was lots of opportunities to test Zebediah, the Zenith Z-181 laptop portable PCompatible.

I love that machine. True, it's easier to write on the NEC PC-8201 when seated in an airplane; the Z-181 is a bit awkward to hold, at least if you're my size and crammed into a tourist-class seat. If you're shorter or in first class, it's no problem. Either way you'll be able to see the screen fine: the blue backlit screen is readable in all light conditions. Incidentally, I keep hearing about restrictions on using portable computers on airplanes, but I have yet to have any of the aircrews do more than admire the Z-181.

Once on the ground, you have a full, fast IBM PCompatible.

I took Zeb down to the AAAS newsroom to log on to BIX and send some items into Microbytes. Zeb was the hit of the newsroom: I think at least three colleagues decided to buy one.

Meanwhile, the NEC MultiSpeed arrived. This is also a fast, full PCompatible machine, lighter than the Zenith and somewhat smaller. Like the Zenith, it has two 3½-inch floppy disk drives, comes with a full 640K bytes of memory, and has provision for a 300/1200-baud internal modem. Unlike the Zenith, it has a handle. It doesn't come with a case, but it will fit nicely into the Ciao! bag I bought

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.

for the NEC PC-8201.

The MultiSpeed comes with considerable built-in software. There's a built-in help feature activated by a special key, and also a Popup hot key that gives you many SideKick-type features, including a notebook. The Popup feature has a filer that lets you store and browse through the equivalent of 3 by 5 cards. It has an outliner, a phone dialer, and a bunch of other stuff. The whole thing is so impressive that I'm going to see if I can find similar utilities for the Z-181.

In other words, the MultiSpeed has some very fine features indeed.

The MultiSpeed also has two fatal flaws. Fatal for me, anyway.

First, I can't see the screen very well. I had to turn on the fluorescent lights at 5 p.m. on a spring day in Los Angeles. There's a contrast adjustment, but it doesn't do a lot of good for me. The MultiSpeed screen isn't as bad as the old Hewlett-Packard portable was, but it's not good either. The screen alone would be enough to make me prefer the Z-181 by a lot; I've never been anywhere that I couldn't see Zeb's backlit screen. Of course, I pay for that in battery time: the Z-181 goes three to five hours on a charge, while the MultiSpeed advertises five to seven and has two weeks' worth of nonoperational backup even if the main power fails. That's a feature I wish Zenith had built into their machines.

Second, the MultiSpeed keyboard is just plain lousy. There is the usual IBM-spawned Backslash key between the Z and the Shift key. Then there's the silly Squiggle key between the quotation marks and Return. Between them I can't type with the MultiSpeed flat on a desk, much less on my lap.

Both the MultiSpeed and the Z-181 have too many keys between Home key and Backspace, of course, and the Z-181 has that darned Squiggle where I'd want Return; but the Z-181's Return key is oversize and thus easy to find. The MultiSpeed, for no sane reason, has a narrowed Return key and an oversize]} key in the way.

Now, I may be overly sensitive to keyboard layout. I make a living writing, and I want the best tools I can get. Alas, no computer company in history (with the notable exception of TI) has ever allowed a touch-typist to be in on keyboard design. Instead, they use some genius who pecks at the keyboard with one or two fingers and couldn't care less where the keys are placed. I suppose it's just something we have to endure.

Anyway, between the semivisible screen and the wretched key layout, I find the MultiSpeed hard to use.

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That's a real pity, because there are some good ideas in this machine. In fact, they're good enough to give it another try. Roberta Pournelle doesn't find the screen hard to see at all, even with her contacts instead of spectacles. I'm going to let her carry it for a month and report again.

Moving Data

One real problem with a portable is getting data from it to your regular computer. You can use Zenith's PCXFER program (see last month's report), but it's god-awful slow and not easy to set up the proper cable. You can use Traveling Software's DOS for the Radio Shack 3½-inch disk, but that's a bit awkward too.

A better way is The Brooklyn Bridge from White Crane Systems. This comes with 5¼- and 3½-inch disks and a cable that can connect to either a PC or an AT at one end and your portable at the other. When you're done, the big machine is entirely slaved to the small one (or vice versa). The remote machine's disk drives appear to be additional drives on the local equipment. You transfer files—programs or data—by using the DOS Copy command in the normal way. You can also get at the other machine's printer.

The Brooklyn Bridge isn't particularly fast, but it's faster than PCXFER. It has to be installed by editing your CONFIG.SYS file and rebooting. That turns out to be easy. The instructions are clear, and I don't think it took me more than 15 minutes from opening the package to transferring the files between Zebediah and Zelda. It's certainly the most painless file transfer program I've used. Recommended.

WordStar 4.0

It came as a bundle of disks in an unmarked package, with dire warnings of what would happen to me if I let the secret out early. I understand Wayne Rash got his copy from someone driving by and handing it to him as he walked down the street. In other words, MicroPro went to incredible lengths to prevent WordStar 4.0 from getting out before they were ready to release it.

The result wasn't good enough to woo me away from WordPerfect, but it's darned good. If you use WordStar—especially if you use WordStar but hate WordStar 2000—you'll love this. WordStar 4.0 incorporates all the nifty new features of NewWord and adds a bunch of updates of its own. It still has some problems. For one thing, it won't reformat a paragraph without your telling it to. On the other hand, it's fast enough, and it can print rings around most of its competition. No question about it: version 4.0 moves WordStar up to 1987 and makes it competitive again.

WordStar has always been everyone's second-favorite text editor. If you have many outsiders using your equipment, it's important to have a copy: everyone knows, or should know, how to use WordStar. It has plenty of add-ons, including a good spelling checker and mail merge program, and they're easy to use.

It's nice to see they're bringing the old girl up to date again.

A First Look

One of my biggest problems is memory: I keep several memory-resident programs in Zelda; so many, that programs like Symantec's Q&A, which would normally be my favorite database and might even win me over to its word processor, won't work unless I dump my memory-resident programs, change my AUTOEXEC.BAT file so it won't bring them in again, and reboot. Since I don't really like doing that, I hardly ever use Q&A.

I have the same problem with Ashton-Tate's Framework, which seems a very nice program, but which wants just about all my memory.

There are several possible remedies for this. One, I'm told, is the Cheetah 386 board and a program they furnish. This will, they say, give me the equivalent of a bunch of PCs, one of which can be filled with memory-resident programs, another running Q&A, a third doing Framework, and so forth. It all sounds wonderful, but I don't yet have it.

Then at the Seybold Conference on Desktop Communications, Terry Meyer gave me a demonstration of Quarterdeck's DESQview, which is a windowing system that's supposed to let you use a RAM disk as virtual memory. The notion is that you open a DESQview window and run a program in that; when you want to do something else, you invoke DESQview with its "hot key" and open a new window; you can run another program in there. Understand, both programs are still running, and you can jump back and forth as you like. All the programs have plenty of memory, because DESQview can create virtual memory by swapping in and out of RAM disk, or even your hard disk.

It sounds great, and the demonstration looked wonderful, so it was with some sense of high anticipation that I installed DESQview. The installation instructions in the manual are simple enough to follow. The result was utter disaster.

It was probably my fault. The DESQview manual is pretty long, and I didn't read all of it. I did follow their instructions, and where I had doubts I tried to look things up in the index.

The first disaster was caused by my memory-resident programs. You can invoke DESQview just fine with SuperKey and SideKick in memory, but if you then try to run a program—say, Crosstalk—the computer goes off into the Bit Zone, and nothing you can do, short of turning it off, will bring it back.

Fine, thought I. Since SideKick is supposed to run under DESQview, and DESQview has its own macro program so you don't need SuperKey, I'll just eliminate all the memory-resident programs and start over.

I also read the fine print and discovered that if DESQview hasn't been told to do otherwise, it swaps your programs and data in and out of the root directory of your hard disk. Clearly I wanted to tell it to use the RAM disk for that, so I ran the Setup program.

This one tells you it has a "beginner" mode and an "advanced" mode. I figured I better stick to "beginner." Wrong. Beginners can't specify which disk to swap in and out of. Run Setup again and tell it I'm "advanced." Now reboot without memory-resident programs.

This time DESQview was able to run Crosstalk, and I was able to connect to BIX. It wasn't easy, though: DESQview has a default window size that's pretty small. If you do things right, you can rush in and change that to be the full size of the screen for Crosstalk before the modem times out. If you don't change the window size, you won't be able to see the Crosstalk command line, and commands you type won't get to Crosstalk.

Alas, when you then make connection with your called number, the window does something funny, and the command line vanishes again even though you've now made the window as large as it can get. I could get my command line back by invoking the DESQview resize function, making the window smaller, and then expanding it again; but it was a definite pain in the posterior. Meanwhile, BIX was jerky: DESQview was apparently monitoring the input and doling it out to the screen in little packets.

I had other problems. When I tried to run SideKick, I managed to lock up the machine so that it had to be turned off to recover. Another time I got some really mysterious numbers that looked like a core dump.

Now clearly I am doing something wrong. People I respect, including Andy Seybold, run DESQview and like it a lot. It has got decent reviews. It must work better than I have been able to make it work, and indeed, inspection of the rather complete—if not optimally organized—manual reveals some clues about what may be going wrong. Also, they tell me DESQview 2.0, out about when you read this, will have fixed several of the problems I found.

I'm going to keep trying; I've reason to believe the results will be worth it. Meanwhile, I do advise anyone contemplating DESQview to budget considerable time for study and installation. More next month.

A Few DOS Discoveries

At last count there were 37 computers around Chaos Manor, and while I suppose a majority of those run PC-DOS in one form or another, there are plenty of examples of other systems. After all, I still write my books on an ancient CP/M system.

Consequently, I'm continually discovering things about DOS that many users have long known.

For example, there is a minimum size to disk files no matter how little you put in them. On the Z-248 under DOS 3.1, that happens to be 2048 bytes; meaning that 20 tiny batch files will take up at least 40K bytes of disk space. This isn't much

continued

of a problem if you have a 30-megabyte hard disk, but it can be a real pain for those who have to run off floppies.

A little trick I've recently learned involves buffers. PC AT machines like Big Kat, the Kaypro 286i, and Zelda are so much faster than ordinary PCs that you tend to accept what they give without thinking of improvements; but the other day I noticed that if I asked for the directory of a disk area that had a lot of files, I'd first get smooth scrolling, and then suddenly the system would change modes, putting up one item at a time and clicking the disk head like mad.

"Some kind of buffer problem," I thought, and recalled I'd heard of a "buffers" command in DOS. I looked into my CONFIG.SYS file, and sure enough, nothing about buffers. Then I looked up "buffers" in Chris DeVoney's *Using PC-DOS* (Que Books, 1986). The discussion was enlightening.

CP/M had a command processing area and a temporary file area, or TPA. The disk buffer area, where disk information was stored prior to being used by the system, was in the CP/M reserved area, and while it might be modified when you set up the system, it wasn't anything the casual user could change. DOS, however, lets you set aside any number of 528-byte buffers and change that any time you care to reboot the system. As soon as I put `BUFFERS = 20` into the CONFIG.SYS file, the machine began showing me truly enormous directories without the hunt-and-peck click/clack I'd got before. It also speeded up other disk I/O jobs.

I'm sure I haven't set aside enough buffers yet, and when I get a little time ahead I intend to experiment.

Meanwhile, those who, like me, never quite learned DOS would do well to look at some books beyond "how to use it" guides. One useful book is Jonathan Kamin's *The MS-DOS Power User's Guide* (Sybex, 1986). I've never been fond of the term "power user" (nor do I know what one is), but this book does have a good discussion of how to organize disk files, how to use batch files, and how to customize your screen.

Van Wolverton's *Supercharging MS-DOS* (Microsoft Press, 1986) is even more useful and a great deal more complete. It's also denser and a bit harder to read, although any interested user should get through it with no real problems.

Wolverton and Kamin overlap about 80 percent, but it's actually worth having both books, since their approaches are somewhat different.

Sometimes We Win One

Last month I reported on the difficulties I'd had setting the CompuPro ARCNET PC board to its proper address.

I've just received the new CompuPro documents for that board. Mark Garetz, marketing vice president, says, "You'll note that we've taken your advice and made the section on setting the node number much easier to comprehend. It now has decimal numbers and a picture of each switch for all 255 possible node numbers."

It does, too. We just got a new AT&T 6300 Plus, with color monitor, and I set it up for Roberta; installing the network (we gave the 6300 Plus a network ID of 63, naturally) was a snap. Since WordPerfect 4.2 works *fine* with the network, we can now trade files back and forth. I love it.

ExperTelligence Common LISP

One of the most impressive booths at the Mac Faire was ExperTelligence's. Its expert-system artificial intelligence programs weren't finished, but they were startling. I spent an hour at that booth.

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One product they do have finished is LISP for the Mac.

LISP is an odd language. The name comes from "list processing," although detractors say it's an acronym for "lots of insane stupid parentheses." LISP can be learned from books, but the easiest way is to hang around people who use it. The second easiest way is to bang away at a machine that speaks LISP. However you learn it, you will very likely believe it is incomprehensible and that anyone who knows the language is not merely odd, but weird. Eventually, though, if you keep at it long enough you will have an aha! experience, and the language will begin to make sense. (LISP haters say that you'll then have gone as mad as the others.)

Despite the fact that LISP is one of the oldest of the higher-level languages, it has not only stayed around but has grown in popularity. Philippe Kahn likes to advertise Prolog as the language of artificial intelligence, but in fact most AI applications—at least on big machines—are done in LISP.

LISP has never caught on as a development language for small computers, for the good reason that it's a memory hog. John McCarthy, the Stanford University professor who wrote LISP in 1956, says it doesn't get interesting until you have a megabyte of memory, and it's not *really* interesting until you have 6 to 8 megabytes. Few micros have either the hardware or software to address that much memory—although Apple's Macintosh II has the potential.

In the past, the most interesting LISP for micros was Metacomco's Cambridge LISP for the Stride Micro 68000 computer line. Now, though, we have ExperTelligence Common LISP for the Macintosh.

ExperTelligence Common LISP is complete and professional enough to use for program development, and indeed, many ExperTelligence AI programs are being written in it. You get a full Common LISP, lots of examples on how to use it, and plenty of tools to help convert from the Pascal way of thinking to "the LISP experience." The documents are professional and well laid out. In many ways, ExperTelligence Common LISP can serve as a model on how to publish a language.

That's the good news. The bad news is the price: $995. ExperTelligence Common LISP is probably worth the cost for someone with a good programming application, but the price is far too high for those who just want to bang around learning the language. They do offer a crippled educational version—no stand-alone programs, no Mac Toolbox access—but it's for universities only, and still costs $195.

Pascal didn't really take off until Borland brought out Turbo Pascal and sold it at a price low enough that any interested computer owner could afford to try writing Pascal programs. I doubt LISP will ever take off the way Pascal did, but it sure isn't going to until we have a lower-cost version.

I really wish ExperTelligence would rethink those prices.

Speed of Light

Last year I reviewed Lightspeed C. At the time this was a program I'd seen in a small booth at the West Coast Computer Faire, and Think Technologies, the publisher, was a pretty small outfit.

Since then Lightspeed C has become the standard C compiler for the Macintosh. Some C enthusiasts say there isn't even a second place. It comes with compiler, linker, libraries, examples, a manual that could serve as a model for others, and up-to-date bug corrections. The li-

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nd they work. The links so fast you ; an integrated en- re of a number of ; you're interested in C for the Macintosh, this is the program to get.

They also have a Lightspeed Pascal. I've had little time to do anything with it, but given the quality of their C, I can't think it won't be a winner. The manual looks well-organized and very complete, and the one program I wrote compiled at least as fast as a comparable C program. Maybe faster. I can't wait to get some time to play with this. I'd also like to see what it can do on the Mac II.

Guide

Some years ago Ted Nelson proposed Project Xanadu, a "hypertext" system. The concept involved linking, on-line and in real time, just about every bit of knowledge in the world and adding to it as new knowledge was generated.

Xanadu is an ongoing project, although incomplete; but the hypertext notion has caught on. Guide, a new product for the Macintosh, is a bold step in that direction. I suppose it's hardly a coincidence that Ted Nelson is a consultant to OWL International, Guide's publisher.

The notion behind hypertext is to link audio, photographs, drawings, maps, motion pictures, and every other form of information into a seamless whole that can be accessed through an indexing system that looks for ideas, not specific words and text. While Guide can't quite do that—not on a Macintosh, anyway—it can link a number of information forms. Guide is a word processor, outline processor, and information linker.

Most of the programming for OWL is being done in Edinburgh, Scotland, which probably explains why its suite at the CD-ROM conference was stocked with single-malt whiskey. When I asked about the notorious Scottish weather, Robie McLaren, product manager, said, "Och, it keeps the programmers inside and working. Now if we could only keep them away from the whiskey." Having been to Edinburgh, I quite understand.

The key notion behind Guide is the "button," which is merely a live area on the screen. When you discover a button and click the mouse, you get action of one kind or another. Guide lets you control those actions: generally something pops up onto the screen, either in an overlay across the original display or in a special window somewhere. The result can be an annotated calendar, text with live footnotes, annotated graphs and drawings, or indeed about anything you can imagine doing on a Macintosh. You can write a guidebook with the ability to click on any place name and get a map. Those maps could have buttons, allowing you to zoom down to any level desired.

In addition, I have seen a program written with Guide that takes you on a guided tour of a videodisc; as you click various items on the computer screen, the relevant portions of the videodisc are found and displayed on a TV screen.

I can imagine Guide being used to make special indexes and guided tours through CD-ROM disks. The only real limit to the way the information can be organized is the designer's imagination. The program works smoothly, it's easy to use, and unique so far as I know. If you do presentations, or you're just interested in organizing information, you'll want to look at Guide. Highly recommended.

MacNosy Version 2

The Apple people are almost speaking to Steve Jasik again. Some of them are even polite.

continued

Jasik's MacNosy was the first program that let hackers explore the innards of their Macintosh ROM set. It's a powerful disassembler, easy to use if you know something about assembly language, and it will let you look into ROMs, system files, and in general any Macintosh programs that intrigue you. You can, if you're ingenious, use it to remove copy protection, find traps, search source code for specific references, and generally go wandering about inside programs.

Version 2 comes with the Debugger, Jasik's version of DDT (Dynamic Debugging Tool) for the Mac. (Incidentally, the original DDT was apparently written at MIT by the Model Railroad Club.) Debuggers let you watch what's happening inside a program as it runs; they're not a lot of use to people who aren't trying to get a fundamental understanding of how programs work. If none of this makes sense, apologies: debuggers are mostly useful to hackers.

Jasik's Debugger isn't complete, but he has a good update policy. If you do or want to do program development on the Macintosh, you need MacNosy with the Debugger. Recommended.

T/Maker is an odd company, in that it doesn't sell its most famous product. The original T/Maker was written by Peter Roizen who, having decided he didn't want to be involved in running a company any longer, took his product and went away, leaving this perfectly good publishing outfit to be run by his sister Heidi.

WriteNow

One of the T/Maker Company's products is WriteNow for the Macintosh. This is a straightforward text editor/word processor, distinguished by having about the clearest manual I've ever seen. The explanation on how to use a word processor starts with the assumption that you don't know much—indeed, anything at all—about writing with computers. It then takes you through creating text, editing it, and saving it; after which it begins a new section on spelling checkers, footnotes, and advanced features.

WriteNow is the product of a cast of thousands. It was originally suggested by Steve Jobs, and indeed is owned by his Next Inc. The manual was written by Caroline Rose and Lisa Kelly. There are programming credits to Jobs, Andy Hertzfeld, Bob Bowen, and many others.

With all that connection to the old Mac team, it's no wonder that WriteNow is very "Macintoshy"; that is, it makes full use of the mouse and other Mac special features, like graying out icons that aren't applicable at present. It also doesn't have many "command key" commands, which some will find a virtue. I personally think it's a defect. When I write, I like to fiddle with text. I try new words and phrases to see what they look like. Insert stuff here and delete it there. I want easy and fast commands, like WordStar's Control-t to delete a word and WRITE's Control-y to delete to end of line. I don't want to have to drag the mouse to mark a word or phrase, then hit Backspace to kill it.

On the other hand, some people like that a lot. One day, I hope, most programs will have both approaches: easy-to-learn features involving icons and the mouse and easy-to-use features involving command keys. I suspect the Mac II, with its function keys, will do just that.

The best way to describe WriteNow is that it looks like MacWrite had died and gone to heaven: it does what MacWrite does, and does it faster and more reliably. Then it adds features like footnoting and multiple column printing, and packages the whole thing with a clear, complete, and well-indexed manual.

I suppose there are more elegant word processors, but this one is easy to learn, easy enough to use, and not very expensive. Recommended.

Modems and Communications

For the past two years, I've used OmniTel's Encore 1200 PC modem card in Lucy Van Pelt, then Big Kat, and now in Zelda. It has always worked fine. My son Alex runs a bulletin board from the companion stand-alone model; it gets a lot of use without complaints. OmniTel modems are rugged, reliable, and simple. They can be addressed to ports 1 through 4 with no difficulty, and they're as Hayes-compatible as modems can get.

I've finally had my first difficulties with my two-year-old Encore 1200. What happens is that it dials the number, and I hear the ring, answer, and carrier; but the modem refuses to believe that it has heard the carrier and finally times out. When it does that, it is sometimes hard to make it hang up.

The proper communications software would let you overcome that problem by manually commanding the modem to go listen to that carrier, whether detected or not; but alas, Crosstalk, which used to come with OmniTel's internal modems (they now come with BitCom), doesn't have that capability. Indeed, Crosstalk doesn't even want to let you control your phone and modem. As an example, suppose you want to dial a local access number on a hotel phone, then quickly plug the cord into the modem and connect.

No go. If you set up Crosstalk with all the correct data, stop-bit, and baud-rate parameters, and leave the "number to

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dial" field blank, when you tell Crosstalk to connect, it gives an error message. How dare you dial the number yourself! Crosstalk insists on doing the dialing for you, even though that may be terribly inconvenient.

That's a real pity, because I often find myself in situations in which I want to take control of the modem and do something that isn't in the books. I am told there are a number of communications programs more flexible than Crosstalk. I certainly intend to try them in the future.

Meanwhile, I'm about to replace my Encore 1200 with the Encore 2400HB internal modem. The 1200, incidentally, is still covered by OmniTel's two-year warranty. It has also been overtaken by technology; whereas my 1200 takes a full slot, the new versions of both the Encore 1200- and 2400-baud modems take only a short (half) slot.

The Encore 2400HB is a beautifully made board. Up to now I've never needed 2400-baud capability, nor had any way to test it. I understand they're setting up a 2400-baud BIX line Real Soon Now. I can hardly wait. Meanwhile, I'm angling to get another Encore 2400HB for my associate, Barbara Clifford, so we can try long-distance file transfer.

Incidentally, the internal modem in my Z-181 portable is also made by OmniTel, and I've never had a bit of trouble with it.

We have had some terrible problems with line noise causing interference on the Zenith Zoom modem for PClones. That modem has a built-in Demon Dialer, which is an interesting feature; but it looks as if the software used is critical. Noise that would upset me, but not faze the Encore, seems to cause the Zenith Zoom to hang up. More on that when I know more.

Items Discussed

DESQview 1.3 .... $99.95
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(213) 392-9701

Electric Dragon $34.95
Baen Software
260 Fifth Ave.
New York, NY 10001
(212) 532-4111

Encore 1200HB $195
Encore 2400HB $399
OmniTel Inc.
5415 Randall Place
Fremont, CA 94538
(415) 490-2202

ExperTelligence Common LISP $995
ExperTelligence Common LISP II $1195
ExperTelligence Inc.
559 San Ysidro Rd.
Santa Barbara, CA 93108
(805) 969-7874

Guide.............................$134.95
OWL International Inc.
14218 Northeast 21st St.
Bellevue, WA 98007
(206) 747-3203

Lightspeed C.........................$175
Lightspeed Pascal...................$125
Think Technologies Inc.
135 South Rd.
Bedford, MA 01730
(617) 863-5595

MacNosy 2.0 .... $90
Jasik Designs
343 Trenton Way
Menlo Park, CA 94025
(415) 322-1386

NEC MultiSpeed................. $1995
NEC Home Electronics (U.S.A.) Inc.
Personal Computer Division
1255 Michael Dr.
Wood Dale, IL 60191
(800) 323-1728

The Brooklyn Bridge...........$129.95
White Crane Systems
6889 Peachtree Industrial Blvd.
Suite 151
Norcross, GA 30092
(404) 454-7911

The Uninvited $49.95
Mindscape
3444 Dundee Rd.
Northbrook, IL 60062
(800) 221-9884

WordStar 4.0 ....$495
MicroPro International Corp.
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200

WriteNow.............................$175
T/Maker Company
1973 Landings Dr.
Mountain View, CA 94043
(415) 962-0195

Winding Down

I'm out of space, and my desk is still covered with stuff I haven't mentioned. I have a full report on the Okidata printer line from Alex, who's been using them at Workman and Associates. Incidentally, Workman reports that a 68000 code generator for FTL Modula-2 is just about done; they'll have FTL Modula-2 for the Atari ST well before the end of the year.

There's MindWrite, a word processor and outline generator for the Mac. New refinements of Q&A. Tornado Notes, one of the niftiest little memory-resident programs I've ever seen. On that score, I have to mention how useful Living Videotext's Ready! has been: whenever I get a notion for this column, I can jot it down in Ready! regardless of what I may have been doing beforehand.

The minor book of the month is by James H. Reynolds, *Computing in Psychology* (Prentice-Hall). This is a discussion of the influence of the computer revolution on academic psychology, with material on models of mind, using computers to generate test scores, and such.

The major book of the month is Marvin Minsky's *The Society of Mind* (Simon and Schuster). Marvin originally invited me to collaborate on this book through the old ARPANET, but the mechanical and scheduling difficulties were too great. That's just as well, because I'm not sure I'd have had anything to contribute. *The Society of Mind* is a tour de force; if you've ever wondered how machines can think, or for that matter how you think, you can't fail to get insights from this book. You may not always agree with Minsky—I certainly don't—but you can't ignore what he says. I don't lightly label a book "important." This one is.

The game of the month is The Uninvited, from Mindscape, for the Macintosh. It has a really neat user interface combined with difficult puzzles: as if you had combined Wizardry and Zork.

We're less than halfway into 1987 and already we've got the Atari 2000, the Mac II, and other exciting stuff. I won't tell you how I know which ones will be important, but if you'll excuse me, I have to go generate a hexagram . . . ■

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.

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Processor Wars

Bruce Webster

Bruce's swan song includes looks at the Mac II and Professional Pascal

Boy, when it rains, it pours. As I mentioned last month, the Access 386 showed up on my doorstep. A week or so later, an Apple IIGS appeared—the one that Apple had lent to BYTE. And a week after that, I found myself in Cupertino, looking at the latest generation of Macintoshes. Things are definitely heating up around here, and I'm scrambling to keep up on everything. This month, I've got my thoughts on the new Macs, some hands-on experience with a 386-based system, and a look at the best Pascal compiler I've ever seen, along with the usual odds and ends. So let's get started.

The Macintosh II

Sitting next to me is the June 1977 issue of BYTE, predating the issue you're holding by exactly 10 years. On pages 14 and 15 is an ad for the Apple II with the headline, "You've just run out of excuses for not owning a personal computer." I can close my eyes and remember just how badly I wanted that computer, but as an undergraduate student with a wife and child, I couldn't come up with the bucks. (I settled for an HP-67 calculator, which I still have.) And the price (over on page 17) was so incredibly low: A 48K-byte Apple II—without monitor, RF modulator, disk drives, or even a cassette tape deck—was just $2638 (and that included free shipping and the famous brown vinyl Apple carrying case).

That 48K-byte Apple II came with 8K bytes of ROM, had a 40-character by 24-line uppercase-only text display, and included two graphics modes: low-resolution (40 by 48, 16 colors) and high-resolution (280 by 192, 6 colors, sort of). It was definitely hot stuff. Throw in two disk drives (140K bytes each) with a controller at $890 and the famous Sup'r'Mod RF Modulator at $29.95, and you're looking at a total system price of around $3560.

It's now 1987, and the cost of that Apple II in today's dollars, adjusting for the inflation of the last 10 years, is about $6800. What can $6800 buy from Apple now? How about a Macintosh II with 1 megabyte of RAM, an 800K-byte disk drive, and a keyboard for $3898. Add the following: a 3½-inch internal 800K-byte disk drive at $299; a Mac internal 20SC hard disk at $999; a Mac II video card (with expansion) at $648; and a high-resolution RGB monitor at $999. That's a grand total of $6843.

For a little more than the price (adjusted for inflation) I would have paid in 1977 for that 48K-byte system, I can now get a Macintosh II with a 15.67-megahertz 68020 processor, 1 megabyte of RAM on a 32-bit data path, a 68881 floating-point coprocessor, 170K bytes of ROM (the rest of the 256K-byte ROM is empty), six NuBus expansion slots, two 800K-byte 3½-inch disk drives, a 20-megabyte internal hard disk, and a 640 by 480 RGB display with 256 colors out of a palette of more than 16 million colors.

Ten years do indeed make a difference.

What do I think of the Macintosh II? Hard to say, since I have yet to spend any appreciable length of time working on one (and believe me, I hope to remedy that as soon as possible). But here are my thoughts, based on notes I took during my daylong visit to Apple and conversations I've had since the Mac II was officially announced.

My overall impression is that Apple did as many things right on the Macintosh II as they did wrong on the original Macintosh. The original Mac was a closed box with lots of drawbacks and arbitrary limitations. It was not designed to be easily or cheaply expanded (remember Apple's $1000 upgrade to 512K bytes?), but it had insufficient resources to suppor the operating system and user interface built into it.

Yet there were some significant breakthroughs in that user interface, significant enough that everyone from IBM on down has tried to find ways to incorporate them in the systems they produce. The IBM PC may be the most widely copied piece of hardware, but the Mac user interface—despite the grumblings and over the protests of the "real men don't use icons" camp—is the user interface most manufacturers would love to have on their systems.

The Mac II has the best of both worlds. It has the Mac system software and user interface, but it also has the wide-open architecture of the Apple II and the IBM PC. In fact, the Mac II appears to be about as wide open as a box can get. Motherboard memory is expandable to (theoretically) 128 megabytes, if you assume that 16-megabit chips will ever be produced. You can also stick memory in the slots, getting up to 2 gigabytes there. I don't know that anyone will ever actually upgrade a Mac II that far, given the problems of chip density, cost, and air conditioning. On the other hand, the thought of upgrading an Apple II to 1 megabyte seemed ridiculous 10 years ago, especially in light of RAM prices ($600 for 16K bytes). Yet I have 1.25 megabytes of RAM on the IIGS si ting over in the corner, using 256K-bit chips that currently cost less than $3 each, meaning that you pay about $25 per 256K bytes of RAM.

Third-party firms have leapt right into the open architecture. For example, AST announced a 4-megabyte expansion card, and National Semiconductor announced one that—with a motherboard/daughterboard combination—can hold up to 16

continued

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megabytes. Setting aside one slot for the video interface, you could then expand your Mac II to 80 megabytes. Of course, that would cost you somewhere around $21,000 for the chips alone, assuming you could get 1-megabit chips for $30 a pop. But, hey, it's nice to know you could do it, right?

Could someone actually use 80 megabytes of RAM on a desktop computer? Yes. I have a friend, Jay Ekstrom, who specializes in building text-retrieval systems. One product he helped develop, EveryWord, has the entire King James version of the Bible in compressed format and will retrieve and display—very quickly—all verses containing a given word or set of words. He says that he'd love to have a computer with 50 to 100 megabytes of RAM on it, so that he can pull large amounts of text (20 to 40 megabytes) into memory for compression and index generation.

Of course, it'll be a while before anyone hangs more than, say, 10 or 20 megabytes on a Mac II, simply because the uses for that much memory have not been developed—yet. Also, too much RAM upsets the "golden triangle" of balance between processor power, memory, and mass storage. However, the growing capacity of hard disks (Apple is offering an internal 80-megabyte hard disk for the Mac II) and the advent of optical disk storage should restore things to balance.

Another bright move on Apple's part was removing the video hardware from the motherboard. Some of you may remember my criticizing IBM many months ago for having done the same thing on the IBM PC and may feel that I'm being hypocritical. But there's a big difference: IBM did not have QuickDraw in ROM. Also, it didn't have the Window Manager, or the Menu Manager, etc., etc., etc. For that matter, IBM didn't have much of anything in ROM, especially in the way of graphics. The result was that the third-party software companies had to decide which graphics standards to support—CGA, EGA, Hercules, and/or PGS—and then modify their code accordingly.

Not so on the Mac II. The enhanced version of QuickDraw—which includes true color support, not the rather primitive stuff in the original QuickDraw—lets developers not concern themselves too much about the exact resolution of the display. If you want to stick with Apple's video board, that's fine. If you want the 1024 by 768 RGB monitor and video card from SuperMac—which still gives you 256 colors out of 16 million—you can get that instead. And if you want the 1664 by 1200 LaserView monochrome display from Sigma Designs, you can go that route.

Most important: If you want all three on the same Mac II, working simultaneously, you can have it. In fact, you could hook up to six displays (one per slot) to the Mac II, and the displays will all work together, much as the Mac screen and the Radius FPD did (as I described last month). Ironically, this gives the Mac a capability that I used on the Apple II while developing software for it: running a text screen off an 80-column card while viewing color graphics via the composite video port. With two displays on a Mac, you can—in theory, I haven't done it yet—test and debug code on one monitor while viewing the output of that program on another.

Another plus: self-configuring expansion hardware. As on the Amiga, the Mac II requires cards for its slots to configure themselves. They can do this based on information actually given by the slots. I hadn't thought about this much until I tried to add RAM to the Access 386 machine; now I remember just what a pain hardware expansion can be. How many of you have had to wrestle with configuring multiple parallel ports on an IBM PC (or clone)?

Speaking of which, there's been a certain amount of hoopla over the third-party coprocessor boards for the Mac II (and Mac SE) allowing you to run MS-DOS software. Given the cheap

continued

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price of MS-DOS clones, I don't see this as a large selling point; that is, I don't expect thousands of people to go out and buy a Mac II or Mac SE because they can then spend a thousand or two more to get it to run MS-DOS software. I do see it, however, as a way around the requirements at many corporations that their computers be able to run MS-DOS software.

What makes far more sense is the effort by Apple and third-party folks to facilitate data transfer between MS-DOS 5¼-inch disks and the Mac. All most folks want to do anyway is to copy their Lotus 1-2-3 files over to Excel, or their Word 3.0 files back and forth between the two machines. You're probably best off buying a cheap MS-DOS clone and the MS-DOS disk option for the Mac II (or SE). That way, you've got two different machines to use, but you can transfer information between them with relative ease.

Additional cheers have come from the Unix community over Apple's planned support of A/UX, a version of Unix for the Mac II. I am not an ardent supporter of Unix, but I suspect this option will open a lot of doors, especially in universities and scientific/engineering environments. As it currently stands, there will be little communication between the Mac OS and Unix, though I expect that to change. However, Unix will be able to access the ROM Toolbox routines, which again will give the Mac II a marketing edge over many other 68020-based workstations.

At this point in time, I have no real negative comments about the Mac II; that'll probably take some hands-on experience. My closest thing to a complaint is that the video-card approach to graphics tends to block page flipping, since the only graphics RAM is that on the card itself. I suspect, though, that some video cards will let you expand memory beyond what the corresponding display requires, so that you can have multiple screen images on a single card and quickly switch between them.

Some have said that the Mac II is what the Macintosh should have been three years ago. I disagree. The Mac Plus is what the original Mac should have been back in January 1984. The Mac II is what the Lisa should have been four years ago . . . except, of course, that neither the 68020 nor the 68881 was available back then. RAM was a lot more expensive, as were high-resolution RGB monitors. But the general architecture and approach are what the Lisa should have had; if that had been the case, this system might have been named the Lisa II.

(Somewhat off the subject: Do you think Apple will ever release a Mac III? Given the still-prevalent negative impressions of the Apple III, which ultimately—once the bugs were out—was an excellent machine, I doubt it. Maybe a Mac IIe, with a 68030 processor, but I don't think we'll ever see a Mac III.)

What does the Mac II compete against? Mostly the likes of DEC, Sun, Apollo, HP, and other firms that produce high-powered individual workstations. Most of those workstations start at $10,000 and climb rapidly when you add little things like hard disks, extra memory, or color displays. But the Mac II has a critical advantage over these other systems: software. Hundreds of well-written, useful, and (most important) relatively inexpensive software packages for the Mac are on the market, and many (if not most) of them will run on the Mac II. Can you run Excel on a Sun 3? Or Helix on an Apollo? Or Word 3.0 on a MicroVAX?

The Macintosh II isn't a computer for the rest of us, any more than the Apple II was 10 years ago. It's a computer for pioneers, tinkerers, hardware junkies with deep pockets, and power users who want to see just how far they can push the hardware and software. And because of its wide-open architecture, the Mac II is a computer that could easily be around in some form a decade from now. Even at its premium price, the Mac II will do well; I'm sure that Apple will sell as many as it can make for some

continued

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time to come. Perhaps the highest accolade I can give it is this: The next computer I pay for out of my own pocket will almost certainly be a Mac II.

The Macintosh SE

The Macintosh SE is the Mac Plus completely redesigned. The only thing the same is the CRT. The case has roughly the same design, but with a number of changes. The motherboard has been redesigned. One PAL chip takes the place of 19 chips; and an expansion "slot" (pin-out, actually) eliminates the gymnastics that third-party hardware manufacturers have had to go through to expand the Mac Plus. There's room enough inside for two 800K-byte drives, or an 800K-byte drive and a 3½-inch hard disk. ROM has been expanded to 256K bytes, though only about 170K bytes is actually being used now.

The Mac SE is a good addition to the Macintosh line, especially given the hot sales of the Mac Plus over the past 6 to 8 months. It gives a more open architecture to those who want it, without the heavy investment in hardware that a Mac II requires. And it still has the small footprint of the original Macintosh. I foresee the Mac Plus dropping in price and the Mac SE selling heavily into the current Mac Plus market.

It's hard for me to get terribly excited about the Mac SE. It's a good machine and represents the next logical filler between the Mac Plus and the Mac II. But I wouldn't buy a Mac SE. Not that there's anything wrong with it; I'd just rather save my pennies and aim for a Mac II, to get something that I can be using and that will still be selling years from now.

The Access 386

I feel funny talking about the Access 386. I've used this system—in fact, I'm using it to type these very words—for more than a month, and yet I don't have a whole lot to say about it except for this: I'm going to hate to see it leave.

What is it? Well, it's a fairly large system that has a 16-MHz 80386 processor, 640K bytes of RAM, a 30-megabyte hard disk, a 1.2-megabyte floppy disk drive, a high-resolution color monitor with EGA board, a RAM expansion board, and enough parallel and serial ports to choke a switch box. The 386 uses a full 32-bit data bus, and the whole system screams along. It's a big change from my previous MS-DOS system: a Compaq portable (the original model), with two 360K-byte drives, 640K bytes of RAM, and a 4.77-MHz 8088.

How does it perform? Table 1 shows some simple bench-

continued

Table 1: *Timings for Turbo Pascal running on an Access 386 system (16.57-MHz 80386) and a Compaq portable (4.77-MHz 8088). The Sieve test executes 50 iterations of the Sieve of Eratosthenes; the Sort benchmark initializes and sorts a list of 10 names 500 times; the IMAT benchmark multiplies two 50 by 50 integer matrices; the RMAT test multiplies two 50 by 50 real matrices; and the Reals test performs floating-point arithmetic in a loop. (All times are in seconds.)*

Test	Access 386 System		Compaq Portable	
	compile time	run time	compile time	run time
Sieve	0.8	7.8	4.3	70.2
Sort	0.9	16.2	5.0	117.9
IMAT	0.9	3.5	4.4	38.2
RMAT	1.0	9.7	4.9	86.5
Reals	0.8	9.4	3.9	67.6

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marks run on two machines: a Compaq portable (4.77-MHz 8088) and the Access 386. This is exactly the same object code in both cases. As you can see, there's a fair difference in speed between the systems . . . on the order of 5 to 10 times.

That speedup appears in using applications as well. Word processing is great, as is spelling checking. Program development with systems like Personal Pascal and Microsoft C becomes painless, despite large library files and multiple-pass compilers. Everything performs faster, and significantly so. It's much like switching from a regular Macintosh to a Levco Prodigy 4 (or a Mac II).

This is my first time using an EGA display . . . and I like it. The text is crisp and clear, and yet I can get high-quality graphics on it. The 43-line display option worked fine with CodeView but wouldn't work with the version of Brief I have; I don't know exactly where the problem is.

Unfortunately, the documentation is poor: sketchy, incomplete, wrong in many places, with too many spelling and punctuation errors. As I said, this is definitely not a system for the novice.

All in all, despite the high performance, this system—at least the one I got—is still a little undercooked. In fact, I suspect this unit is not an "off-the-shelf" system, but one of the early models that still has a few bugs in it. Like the problem with the memory card . . .

RAM in the Thick of It

I don't know why I tend to start projects like this around midnight, when my chances of getting any kind of technical help are at best slim. You see, my former wife got her Macintosh (our old, original, 3-year-old Mac that we bought three weeks after Apple announced it) upgraded to a Mac Plus, and in the process, I got back the Levco Monster Mac upgrade we had purchased a few years ago. The Levco upgrade was also an oldie—a beta version, in fact, that had been soldered into the motherboard—and I didn't figure it was worth much on the open market. I knew Apple wouldn't want me to install it in the Mac Plus I have on loan from them, so I decided to cannibalize it for RAM. After all, it had 1.5 megabytes of 256K-bit chips on it.

My first upgrade target was actually the IIGS. The IIGS RAM expansion card that Apple had included had only 256K bytes of RAM on it, so I quickly filled it up to a full megabyte (giving the whole system 1.25 megabytes). That upgrade was quick, easy, and best of all it worked, letting me set up a large RAM disk.

Since I still had 0.75 megabyte of RAM left, I decided to do the same to the Access 386. The Access comes with a RAM card named the Challenger. The Challenger can hold up to 2 megabytes (using 256K-bit chips); with a special daughterboard, it can double that. And since the Access 386 is set up to handle two Challengers, you could (in theory) get 8.5 megabytes of RAM on the system (the main system motherboard comes with 512K bytes).

I had been a little disappointed when I saw at boot-up that the Access had only 640K bytes of memory. So when I got the Levco board back, I decided to move some RAM over to beef things up a little. Getting into the machine was a bit tedious, if not particularly difficult: putting the monitor on the floor, unplugging enough cables to swing the back panel around, removing five screws, sliding the whole case forward. There were just three cards in the slots: the floppy/hard disk controller, the EGA (a custom version from Advanced Logic Research), and the Challenger. It took just a few seconds more to unfasten the card and extract it from its slot.

Mistake #1: Before I started messing with the RAM card, I neglected to write down the current DIP-switch settings. There

continued

was already one bank of RAM in it (512K bytes, according to the manual), so I started removing chips from the old Levco board and carefully inserted them in bank #2 of the Challenger, doing a pretty good job of avoiding the bent pin syndrome.

I got all 18 chips in (512K bytes of RAM with parity checking), set the DIP switches on the card according to the book, put things back together, plugged the power cable back in, and powered up. I got a message from the system that the memory configuration it remembered (in battery-backed RAM) wasn't the same as it was reading in. Fine, I thought, that makes sense; and so I changed it and rebooted. Same problem still. Made a few other changes. Same problem.

After a stretch of this, I went back through the manual carefully and found a section about jumpers on the motherboard. Sure enough, there was one that I had to switch. I did so. Still the same problem. I went back, double-checked the docs, and found a loose-leaf update of that section, with new switch settings for the Challenger. I changed the DIP switches, put things together again, and rebooted. Same problem.

I spent the next hour or two trying out different combinations of switches. None of them worked. For that matter, I couldn't even get back to the 640K-byte setting I had; the system was recognizing only the 512K bytes on the motherboard.

It was somewhere around here that I realized mistake #2: I hadn't looked closely at the first bank of RAM. Instead of having 256K-bit chips (as the manual claimed), it had 64K-bit chips. A light went on. That's why the Access (prior to my expansion) had only 640K bytes—512K bytes on the motherboard and 128K bytes on the Challenger. There was undoubtedly a DIP-switch setting for 64K-bit chips, but it was certainly not any of the ones I had been using.

Next step: I carefully removed the 64K-bit chips and moved the 256K-bit chips down to bank #1. I now went back and tried the various combinations of jumpers and switch settings. No success. So I finally pulled all my 256K-bit chips and put the 64K-bit chips back in . . . at which point I realized mistake #1. My memory of how the switches had been set before I started was obviously faulty, since I couldn't get back to the 640K-byte system I had before I started. It ultimately took a call to Advanced Logic Research to get things straightened out. Moral: If you're going to use the cutting edge of technology, you might get bloodied in the process.

Product of the Month: Professional Pascal

So you've got an 80386-based system, and you want to write some programs for it. What are you going to use? You could use any of the regular MS-DOS compilers available, but they're not going to make any use of the 386's extended instruction set or, more important, extended addressing. What's a programmer to do?

Enter Professional Pascal from MetaWare. The name is appropriate: This is possibly the most professional Pascal compiler I've ever seen. The language has been heavily extended, and in all the right ways. Yes, it does fully support the ANSI standard, but it doesn't stop there. One of Metaware's advertising blurbs says they're "halfway to Ada," and I like the half they chose.

First off, Professional Pascal completely implements the ANSI standard for Pascal. In fact, you can use a compiler directive to turn off all non-ANSI extensions, so that you have an exact implementation of ANSI-standard Pascal. I don't know why you'd want to do a foolish thing like that; perhaps it's good to have just in case. But you'll probably want the extensions.

Oh, the extensions. As many of you know, I'm a fan of Pascal. It was not my first language—I learned it about 7 years ago, after having programmed in a number of other languages—but

continued

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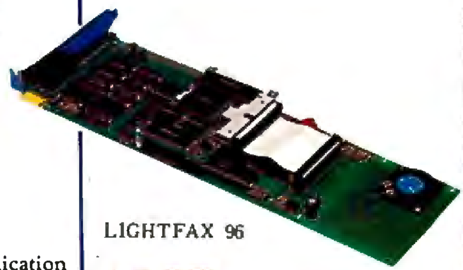

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I've since written more than 100,000 lines of Pascal code, so I know it pretty well, and I'm aware of its strengths and its deficiencies. For me, reading through the extensions manual was like getting every single thing I'd asked Santa for, and then some. MetaWare has incorporated many of the best features of Ada, C, Mesa, and Modula-2, while retaining the basic flavor and strengths of Pascal.

What kinds of extensions? There are a number of little, but useful, ones: extra data types, like `Cardinal`, `LongInt`, `LongReal`, and `ExtReal`; strings with up to 64K characters and sets with up to 64K elements; additional operators, like `or else` and `and then`, which give you "short-circuit" Boolean evaluation; additional built-in functions, like `Min( )`, `Max( )`, `Highest( )`, and `Lowest( )`; additional control commands, like `Exit`, `Halt`, and `Cycle`; and end-of-line comment statements.

These are nice, but some are found in most Pascal compilers. What really sets Professional Pascal apart are the more serious language extensions. Compound statements with internal declarations are permitted, as shown in listing 1.

As you can see, this lets you declare variables (and data types and constants) within a `begin..end` block. The scope of those variables is the block in which they are defined, so they exist only for the portion of the program where they're needed.

Of even greater interest is the "iterator" construct. If you want to create a `for` loop with a special range of values, you can define an iterator—something like a special function—that yields the list of values for the loop. For example, what if you wanted a loop where the index variable went through the squares? You could use the code shown in listing 2a. The `Yield( )` statement gives the next value for the loop; the loop itself terminates once the iterator exits (either through a `Return` statement or simply by reaching the end of the iterator). A loop using this iterator might look like listing 2b.

This loop would now execute with `X` taking the value of the first 100 squares `(1, 4, 9, ..., 10,000)`.

You can also define your own binary operators in Professional Pascal. For example, if you want to define the operator `+*` to return the sum of the squares of two real values, you could use the code shown in listing 3. Professional Pascal will recognize the name `+*` as an operator and will let you use it in infix fashion:

```
Z := X +* Y;
```

In Professional Pascal, you can use any function name in infix fashion, simply by preceding it with a percent sign. Or you can use it in postfix notation by preceding it with an exclamation point. Say, for example, you defined the function `GCD`, which returns the greatest common denominator of two integers:

```
function GCD(I,J : Integer) : Integer;
...
end; { of func GCD }
```

continued

Listing 1: *A source code fragment in Professional Pascal, showing its ability to declare variables local to a* `begin ... end` *block.*

```
for Indx := 1 to 100 do declare
 var
  ISqr     : Integer;
 begin
  ISqr := I*I;
  Writeln(I:6,' ',ISqr:10)
 end;
```


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The following three statements would all be allowable and would operate identically:

```
C := GCD(A,B);
C := A %GCD B;
C := (A,B) !GCD;
```

By the way, functions in Professional Pascal can return just about any data type, including records, sets, and arrays.

I ran some simple benchmarks, to compare Professional Pascal and Turbo Pascal. All compilations and executions were done on the Access 386, off the hard disk. In every case but the Sort benchmark, the same source code was used by both compilers; different implementations of the string data type (the use of parentheses instead of brackets to specify maximum string length) forced me to make one minor change.

Table 2 shows the results of the tests. As you can see, Professional Pascal produced code that was smaller in almost every case and that was as fast or faster in every case but one. However, the run-time support was greater, resulting in .EXE files that were bigger—usually much bigger—than the .COM files produced by Turbo Pascal. (Source code for these benchmarks can be found in the ask.webster conference on BIX.)

The documentation is extensive (around 600 pages), complete, well-organized, and well-written. It's divided into three major sections: Programmer's Guide, which tells how to use the compiler and gives the nitty-gritty, machine-specific details; Programmer's Primer, which is a comprehensive (240 pages) explanation of the Pascal implementation; and Language Extensions Manual (180 pages), which explains all the extensions that have been added. Additionally, there are the usual small sections listing new features, 386-specific information, and so on.

Professional Pascal takes up a lot of disk space and memory; you should at least have a hard disk and 512K bytes of RAM. An

continued

Listing 2: *This example of Professional Pascal code shows how you can use the* `iterator` *operator (a) to create a nonstandard index in a* `for` *loop (b).*

(a)

```
iterator NextSquare(First,Last : Integer) : Real;
begin
 while First <= Last do begin
  Yield(First*First);
  First := First + 1
 end
end; { of iterator NextSquare }
```

(b)

```
for X in NextSquare(1,100) do begin
 ...
end;
```

Listing 3: *Professional Pascal also lets you define new operators; this operator (defined as +*) will return the sum of the squares of two real values and can be used in infix notation.*

```
function +*(V1,V2 : Real) : Real;
begin
 +* := (V1*V1) + (V2*V2)
end; { of func +* }
```

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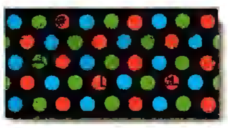

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installation batch file does all the dirty work for you. For example, the compiler alone, when installed and ready to go, is more than 660K bytes in size.

If I have one major complaint, it is (as it is so often) that the package costs too darn much: $895. And you don't even get an editor with it (Turbo Pascal serves well as one). It's a shame that a language implementation this outstanding will never get much distribution, because most programmers are going to be willing to get by with compilers that cost much less (and do much less).

There are also some minor complaints with this, the 386 version, but they all stem from the lack of hardware and a standardized operating system for the machines that have made it out to the market. For example, the current version requires you to have the 386/ASM-386/Link package from Phar Lap Software; you use the linker (LINK386) to link your object modules and a special program (RUN386) to actually run your .EXE file. Together, Professional Pascal and RUN386 support what is known (somewhat humorously) as the "Small" memory model: one code segment and one data segment. Of course, on the 80386, each segment can be 4 gigabytes long, so it's not really very small. The current version of RUN386 (1.1e) limits the load size of the program to 640K bytes, though it gives full memory range to both the data and code segments.

What if you're not developing for the 386-based systems? You can get an MS-DOS version of Professional Pascal for the same price. What if you don't like Pascal? MetaWare also sells a C compiler (called High C) for 386-based systems.

Microsoft C

The other language I've been playing with during the past month has been Microsoft C, version 4.0, for MS-DOS. This version doesn't generate 386 code, but it's a solid, fast compiler that works nicely indeed on the Access 386.

What can I say about the compiler itself? It supports five different memory models (small, compact, medium, large, and huge), three different calling sequences (cdecl, pascal, and fortran), several different processors and coprocessors (8088/8086, 80186, 80286, 8087, and 80287), and lots of library functions. It has several utilities, including MAKE. It has voluminous documentation (three volumes), that is well-written and well-organized.

Its biggest plus is CodeView, a source-level, window-and-menu-oriented debugger. With CodeView, you can pull up your programs; single-step through them; watch the values of different variables, register, and memory locations change; and in short do whatever you need to debug your code.

You really need a hard disk to use Microsoft C effectively. It is possible to get by with two floppy disk drives, but I sure wouldn't recommend it. Heck, you can buy a hard disk for your PC for about what you'd pay for this compiler, so you should invest in the hardware to make the software really pay off.

If my comments seem brief, it is because I don't feel especially qualified to judge C compilers (I consider myself to be pretty much a C novice). I know the language moderately well but have not written enough C code to know what to look for (or not look for) in a C compiler. However, I found Microsoft C and CodeView easy to use. It's my choice for MS-DOS C development for the time being.

C on the PC

Speaking of Microsoft C, I've grumbled before about my inability to find a good introductory text on C. I own close to a dozen

Table 2: *Timings for Turbo Pascal and Professional Pascal on an Access 386 (using the internal hard disk). See table 1's caption for a description of the benchmarks.*

Test	Turbo Pascal		Professional Pascal	
Sieve	compile:	0.8 secs	compile/link:	26.4 secs
	code:	368 bytes	code:	304 bytes
	data:	8240 bytes	data:	8253 bytes
	.COM:	11,753 bytes	.EXE:	25,682 bytes
	run:	7.8 secs	run:	4.0 secs
Sort	compile:	0.9 secs	compile/link:	27.0 secs
	code:	816 bytes	code:	550 bytes
	data:	208 bytes	data:	415 bytes
	.COM:	12,200 bytes	.EXE:	19,942 bytes
	run:	16.2 secs	run:	5.1 secs
IMAT	compile:	0.9 secs	compile/link:	33.9 secs
	code:	848 bytes	code:	568 bytes
	data:	15,040 bytes	data:	15,054 bytes
	.COM:	12,239 bytes	.EXE:	42,844 bytes
	run:	3.5 secs	run:	2.8 secs
RMAT	compile:	1.0 secs	compile/link:	33.9 secs
	code:	896 bytes	code:	630 bytes
	data:	25,040 bytes	data:	20,054 bytes
	.COM:	12,284 bytes	.EXE:	57,972 bytes
	run:	9.7 secs	run:	23.0 secs
Reals	compile:	0.8 secs	compile/link:	28.4 secs
	code:	304 bytes	code:	312 bytes
	data:	80 bytes	data:	69 bytes
	.COM:	11,694 bytes	.EXE:	26,496 bytes
	run:	9.4 secs	run:	2.8 secs

C texts, not one of which really does a good job of presenting C in a clear, logical, orderly fashion. Maybe that's a problem with the effect C has on the minds of these authors, but whatever the reason, it has been a continuing source of frustration.

Well, the frustration has ended. Robert Lafore, whose book *Assembly Language for the IBM PC & XT* I praised last year, has written the best tutorial on C I have read: *Microsoft C for the IBM*, put together under the auspices of the Waite Group and available at $24.95 from Howard W. Sams & Co. Mitch Waite was kind enough to send me galleys of the book, and I worked through it, page by page. My thought on reading it was, "Why hasn't anyone written a C text like this before?"

Lafore covers all the topics you'd expect him to: data types, control structures, functions, pointers, arrays, structures, and files. He also covers several that you wouldn't expect: CGA and EGA graphics, serial ports, modems, separate compilation, and memory models. The emphasis is on using C to make your machine (IBM PC or compatible) actually do something.

If you want to learn C—even if you don't know much about programming—get *Microsoft C for the IBM*, along with a good C compiler, and work through the book. It focuses on Microsoft C, but you could easily use other compilers (Let's C, Instant C, Ecosoft C, and so on). The book is the important part; you won't regret buying it.

Updates

The folks at Access Associates, who manufacture the Alegra memory-expansion box for the Amiga, have now released their 2-megabyte version, thanks to the decreasing cost and increasing supply of 1-megabit chips. The cost for the 2-megabyte version is $475.

I received the Microsoft Word 3.0 upgrade (for the Macintosh) a few weeks back. I was a bit reluctant to change at first, fearing bugs and/or features that would end up causing problems. However, once I started using it, I got hooked. The faster response (especially when repaginating), the new features (including some borrowed from MacWrite), and the overall performance won me over. I still prefer to do my major word processing using NewWord, especially since I've got the Access 386 to play with for the time being. I may switch over to the Mac for major word processing once I get a Mac II, but probably not before then.

The Hackers Corner

Some months back, I wrote about the International font for the Macintosh created by Dr. Paul Rapoport, who teaches at McMaster University. Paul recently sent me his latest efforts. He's made some improvements to the International font (now called International Roman). But he has also created three new fonts: International Greek, International Cyrillic, and International Phonetic.

The International Greek font has already proved helpful. I recently decided to revive the Greek I had learned back in college, using the Mac to transcribe portions of the New Testament for later translation. The Symbol font was woefully inadequate, since it had none of the accents, breathings, or other marks (iota subscript, etc.). A search through my disk files turned up the International Greek font, which I then installed. To my delight, I found it had everything I needed, right down to correct Greek punctuation; for example, it typed ";" (the ancient Greek question mark) when I pressed the "?" key.

continued

Items Discussed

Access 386 .... $4000 and up
Advanced Logic Research
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Alegra Memory Box (2-megabyte version) $475
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The Queue Is Flushed

Well, teammates, this is my last According to Webster column for BYTE. A certain software company wants me to write some manuals for them and has offered me more money than I care to refuse. To avoid questions about conflict of interest, I've agreed to step down. It has been a fun two years, and I am immensely grateful to Phil Lemmons for giving me the chance to write it. My single biggest regret in leaving this column is that I won't be able to get to all the products I have yet to cover; to those whose products will get skipped, my apologies. I'll still be writing for BYTE, doing Programming Projects and System Reviews. Thanks to all of you for your kind words, encouragement, and criticisms over the past two years. Be good, never bias a MOSFET above the source drain, and I'll see you on the bit stream. ■

Thanks to Frank Boosman and Eric Zocher of Silicon Beach Software; Tom Pennello at MetaWare; Rick Russell at BYU; and Mitch Waite at the Waite Group.

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Run-Length Encoding

Dick Pountain

Compress data by replacing repeating items with a count and one item

A few years ago, it seemed that data compression on personal computers might become a redundant art. The price of memory (both solid-state and disk) was going down so fast that compressing data hardly seemed worth the trouble. Such naive optimism has had to yield, however, to advances in telecommunications. The increasing use of on-line systems like BIX makes data compression desirable; you can cut down on your phone bills if the software you download is compressed with ARC (a public domain archiving utility) or a similar system.

At the same time, disk drive manufacturers have discovered a relatively inexpensive way to increase both the capacity and the speed of their products: By compressing data "on the fly" with a custom chip, you can fit more on a disk with less head movement. The same chip expands the data when it is read. A large percentage of the next generation of microcomputer Winchester drives will undoubtedly have such run-length-limited hardware as a part of their design.

Many algorithms are used to compress data, ranging from the very simple to the highly complex, and their efficiency varies according to the nature of the data in question. The simplest of these algorithms, *run-length encoding*, finds runs of repeating items in the data and replaces those runs with a count of the original number of items and a single item. It's a commonsense idea we use regularly in everyday life; for example, we say, "please get me three pints of milk at the store" rather than "please get me a pint of milk and a pint of milk and a pint of milk at the store."

Three's a Crowd

Run-length encoding is easy to implement in a program, but it can be applied at different levels. Moreover, it is efficient for only certain kinds of data, namely, those in which many repeating runs occur. For example:

It's u2terly usele2s for compre2sing ASC2I text data, which typica2ly contains only the o2casional double le2ter or repeated space.

In this case, we accomplished no data compression at all, as the count takes up as much space as the letter it replaces. Run-length encoding shouldn't be applied to runs of one (which would nearly double [i.e., 1d1o1u1b1l1e] the size of the sentence) or two items.

Binary data is a different matter. On a bit-mapped graphics system, for example, the screen data contains many long runs of adjacent pixels with equal values, representing blocks of the same color. These can be run-length-encoded for storage and communication. (Some graphics-file formats for the Macintosh already exploit run-length encoding.) In fact, since only two possible values are present, a 0 and a 1, it is sufficient to record the count alone, with alternate counts referring to 0 and 1 alternately. For example, a black patch on a single scan line of the screen might look like figure 1a and be encoded as in figure 1b.

This scheme treats the screen data as a continuous stream of bits, regardless of byte or word boundaries. However, you need to do a lot of "bit-twiddling" to extract the bits from a stream of bytes or words. In addition, corruption (or loss) of a single byte in the encoded data totally destroys the decoded image. Hard disk encoding systems also treat the data as a bit stream, but they use a custom VLSI chip to perform bit extraction and error checking.

An Easier Way

I've recently been playing with a much simpler scheme for run-length-encoding IBM PC color-text screens. I've written a program that uses a mouse to "paint" text-mode screens on the color graphics adapter, employing a wide range of colors achieved by *dithering*, using the extended ASCII characters 176 through 178. (Dithering means getting the effect of extra colors by putting pixels of different colors next to each other; for example, if you alternate red and green pixels, the resulting color looks like yellow. It isn't a "true" color, because if you look at it closely, you can see the individual red and green pixels—but it does look like yellow. By using all the possible combinations of ASCII 176, 177, 178, foreground and background colors, you can create 120 new "false" colors in text mode.)

The resulting screens are attractive and colorful, but they occupy 4K bytes of memory each. By using run-length encoding, you can usually squeeze them down to 300 to 1000 bytes, making it feasible to include them in the code of a program, for example, as help screens.

An IBM color-text screen (in 80-character by 25-line mode) consists of two thousand 16-bit word values. The 2 bytes in each word contain the color and text data. The first byte represents a color attribute; the second, a character code. Dumping one page of the color-adapter memory to a file in this manner produces a 4000-byte file. Run-length-encoding this data compresses all the areas representing solid blocks of color or repeated characters (like a box frame), although it doesn't do much for English text.

The first design decision you must make is what length of runs you want to encode. As you can see, it is folly to en-

continued

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code "runs" of one and no help to encode runs of two. This means that the encoded file will include two different kinds of data items: those representing a single uncoded value and those depicting the count/value pair for a run of values. An expansion program must be able to distinguish between these two different cases. In the example sentence, I cheated by using a sentence composed only of letters while the counts were digits. This method would not have worked if the sentence had contained some digits.

The Escape Route

The accepted method for making this distinction is to choose one special escape character that cannot represent a data value but indicates that the two values following it are a count/value pair. For example, you could encode the sequence in figure 2a using # as an escape character (see figure 2b). This reduces the overall compression achieved—you need three items to encode any run (one for the # sign itself) instead of two. You should exclude runs of one or two, or you may increase the size of your encoded text.

An escape character must be unique, a bit combination that will never appear in the data. Therefore, encoded files must not themselves be encoded. The algorithm for run-length encoding using an escape character is shown in pseudocode form in listing 1. [Editor's note: *The algorithms discussed in this and future Focus on Algorithms columns will be expressed both in pseudocode and in a programming language. The pseudocode uses control structures similar to those in Pascal or C, as well as the following conventions: Variable names begin with a capital letter; a right arrow indicates an I/O operation; a left arrow indicates an assignment to a variable. Parts of the pseudocode may be described in plain English words; these descriptions will be in lowercase.*]

I decided on a more economical scheme. Since an IBM PC screen contains 2000 words of data, you can express any possible count in 11 bits (2^{11} = 2048). Thus, if you make the escape indicator only 5 bits instead of 8, you can squeeze both the count and the escape indicator into a single 16-bit word, 2 bytes. Any word whose most significant 5 bits are equal to the escape indicator is treated as a count, and the next word contains its value. With this method, encoding runs of two incurs no space penalty—but achieves no compression. Leaving them in simplifies the program logic since you only need to treat singletons (runs of one) differently. This scheme *never* leads to an increase in the size of the color-screen data; in the worst case, it stays the same.

I chose F800 hexadecimal as my escape indicator (all 5 top bits set to 1); therefore, I can't use a screen containing an attribute byte with these bits turned on. This attribute corresponds to a high-intensity, blinking, foreground character on a white background; I think I can live without that combination. Listing 2 contains `Compress`, a procedure in Turbo Pascal that condenses a screen into a file, using this compression scheme. For reasons of space, I omitted the checks I normally perform when opening files.

(a) 000000000000000000111111111111111000000000000000000000000000

(b) 18 15 28

Figure 1: (a) *A section of the bit-map data for a single scan line of a screen containing a black patch on a white background.* (b) *The encoded data from* (a). *Since only 0s and 1s exist in binary data, you need to show only the count.*

(a) 1111111233333333344444 5

(b) #7 1 2 #9 3 #5 4 5

Figure 2: (a) *A sequence of numeric data without any encoding.* (b) *The same data shown in* (a) *encoded with escape characters, count/value pairs, and singletons. This format describes the sequence of data as containing seven 1s, a single 2, nine 3s, five 4s, and a single 5.*

Listing 1: *A pseudocode listing of the algorithm for run-length encoding.*

```
Program Encode
  item from input -> Current
  REPEAT
    Runlength <- 0
    REPEAT
      item from input -> Next
      Runlength <- Runlength + 1
    UNTIL Next NOT = Current OR no more items
    IF Runlength > 1
    THEN (escape character, Runlength) -> output
    ENDIF
    Current -> output
    Current <- Next
  UNTIL no more items
```

The Rest of the Story

Compressing screens is only half the story. You must be able to read the file of condensed data into an array in memory and then be able to expand the data in this array back onto the screen upon request. Since I wanted the compressed data to become part of a program—rather than to be read in at run time—I chose to store it in a Turbo Pascal typed-constant array. `Compress` outputs the condensed data as ASCII text, enclosed in parentheses and separated by commas, rather than as binary information. You can include this array directly into your source text, declaring it in the form `const pic1: array[0..367] of integer = (24631, 31234,...);`. Life is simpler if you keep a count of the total number of data items you have after compression is complete (367 in the example) and write this count as the last item in the condensed file.

An expansion procedure, `Expand` (see listing 3), reads the elements in the compressed array, extracts the count whenever it recognizes the escape indicator, and puts that number of attributes/characters into screen memory in sequence. To make the expansion as fast as possible, I used a memory-fill routine instead of a loop for this purpose. Regrettably, Turbo Pascal has a `FillChar` routine for bytes but none for words, so I wrote `FillW` (see listing 3) as an in-line machine code procedure. [Editor's note: *Listings 2 and 3 are available in Turbo Pascal 3.0*

Listing 2: *The* Compress *procedure written in Turbo Pascal. This procedure will compress a screen into a file using the value F800 hexadecimal as an escape indicator and the remaining 11 bits of data in a 16-bit word for the count. The second 16-bit word will contain the value.*

```
procedure Compress;

const escapechar = $F800;
      scrnseg = $B800;
      scrnsize = 4000;

var OutputFile: Text;
    OutputFileName: string[80];
    runlength,currentword,nextword,scrnofs,items: integer;

begin
  OutputFileName := paramSTR(1);
  Assign(OutputFile, OutputFileName);
  Rewrite(OutputFile);
  write(OutputFile,(');
  items := 0;
  scrnofs := 0;
  currentword := MemW[scrnseg:scrnofs];   {read word from screen memory}
  scrnofs := scrnofs + 2;
  repeat
    runlength := 0;
    repeat
      nextword := MemW[scrnseg:scrnofs];
      scrnofs := scrnofs + 2;
      runlength := runlength + 1;
    until (nextword <> currentword) or (scrnofs > scrnsize);
    if runlength > 1
    then begin                                          {it's a count / value}
      runlength := escapechar or runlength;              {set 'escape' bits}
      write(OutputFile,runlength,,',currentword,,');
      if (items mod 12) >= 10                            {format into lines}
        then writeln(OutputFile);
      items := items + 2
    end
    else begin                                           {it's a singleton}
      write(OutputFile,currentword,,');
      if (items mod 12) >= 11
        then writeln(OutputFile);
      items := items + 1
    end;
    currentword := nextword
  until scrnofs > scrnsize;
  write(OutputFile,'*** ',items, items ***);');
  Close(OutputFile);
  writeln('Compressed data written to ',OutputFileName)
end;
```

source code for the IBM PC and compatibles on disk, in print, and on BIX as COMPRESS.PAS and EXPAND.PAS, respectively; see the insert card prior to page 321 for details. They are also available on BYTEnet; see page 4.]

In the process of writing Expand, I discovered a neat trick. If I reserved a second special attribute indicator (in addition to the escape indicator) and called it *transparent*, I could leave parts of the screen unaltered by incrementing the destination pointer without writing any data. I chose 07FA hexadecimal (a white dot on a black background); areas of the original screen (before compression) painted with this character appear transparent to the background after expansion, letting you design pop-up windows. This is a simple form of cursor addressing that costs nothing at expansion time.

To overcome Turbo Pascal's array-parameter weakness, which lets you pass only one size of array to a given procedure, Expand takes the address of the

continued

Listing 3: *The* `FillW` *and* `Expand` *procedures written in Turbo Pascal.* `Expand` *takes the compressed data generated by* `Compress` *and reverses the process. It recognizes the escape indicator, notes the count, and places that number of characters into screen memory.* `FillW` *is a memory-fill routine used by* `Expand` *instead of a loop to increase the speed of the expansion.*

```
{Fill <count> words of memory starting at <seg:ofs>
 with the 16-bit value <word>}

procedure FillW(seg,ofs,count,word:integer);
begin
     inline
     ($8B / $86 / seg /         {MOV AX,seg}
     $8E / $C0 /                {MOV ES,AX}
     $8B / $BE / ofs /          {MOV DI,ofs}
     $8B / $86 / word /         {MOV AX,word}
     $8B / $8E / count /        {MOV CX,count}
     $FC /                      {CLD}
     $F3 / $AB)                 {REPZ STOSW}
end;

procedure Expand(srcofs,picsize:integer);

const escapechar = $F800;       {binary 1111100000000000}
      transparent = $07FA;
      scrnseg = $B800;          {start segment of video RAM}

var srcptr,destptr,data,runlength,i: integer;

begin
  srcptr := 0;
  destptr := 0;
  while srcptr < picsize * 2 do
  begin
    data := MemW[Cseg:srcofs+srcptr];               {fetch next word}
    srcptr := srcptr + 2;
    if (data and escapechar) = escapechar           {test top 5 bits}
    then begin                                      {it's a count word}
      runlength := data xor escapechar;             {unpack count part}
      data := MemW[Cseg:srcofs+srcptr];             {fetch next word}
      srcptr := srcptr + 2;
      if data = transparent                         {color is transparent}
      then destptr := destptr + (2 * runlength)     {so just bump pointer}
      else begin
        FillW(scrnseg,destptr,runlength,data);      {fill screen memory}
        destptr := destptr + (2 * runlength)
      end
    end
    else begin                                      {it's a singleton}
      MemW[scrnseg:destptr] := data;
      destptr := destptr + 2
    end
  end
end;
```

array, found by the `Ofs( )` function, and the size of the array as parameters; indexing must be done at a low level with `MemW`. You can expand a screen with a simple call to this procedure, for example, `expand(ofs(pic1),367);`.

Words versus Bits

In principle, you can easily modify these procedures to compress IBM PC screens in either of the high-resolution graphics modes. However, compression will be less than optimal since runs of pixels in the picture cross word boundaries, and a program that examines only words will miss many runs (or encode them as several runs). A true high-resolution compression utility needs to treat the screen as a bit stream, which means decomposing bytes using the bit-wise logical operators; it is likely to be slow. You can also modify these programs to form the basis of a communications protocol for transmitting color text over public phone lines. ■

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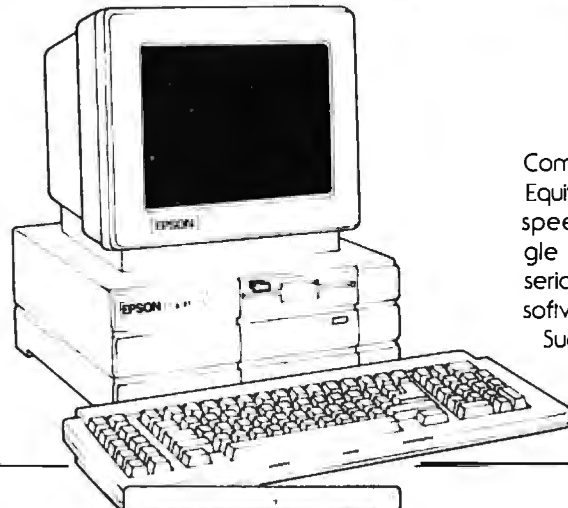

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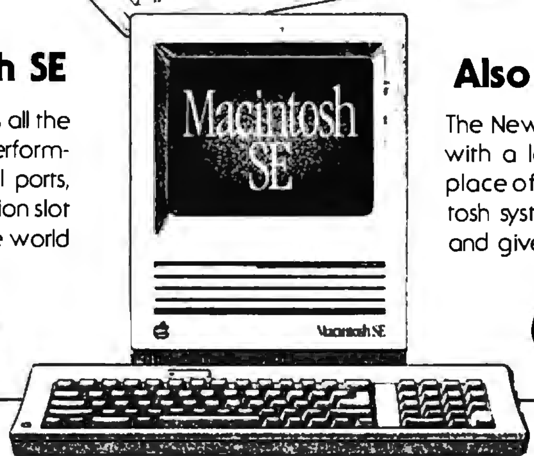

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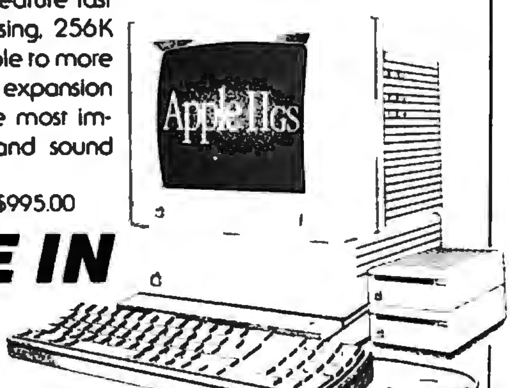

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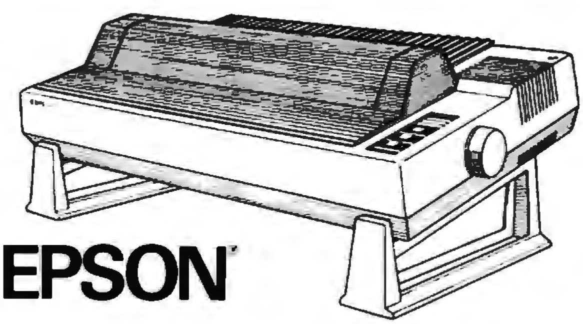

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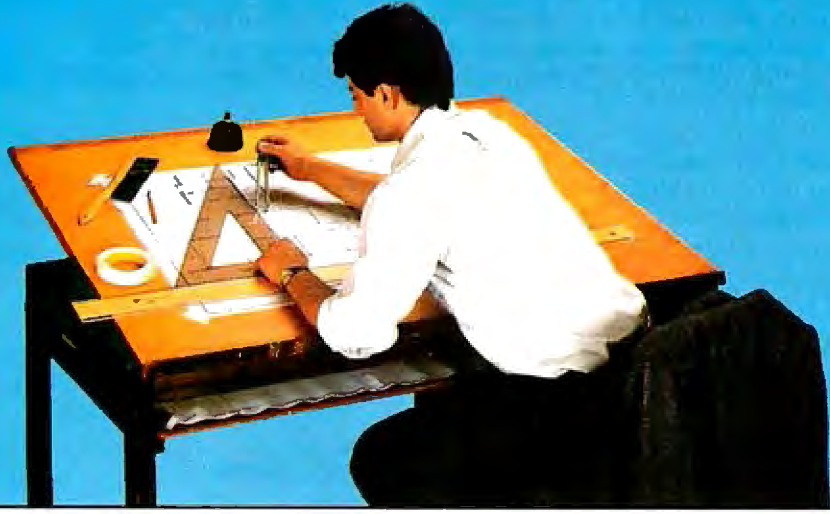

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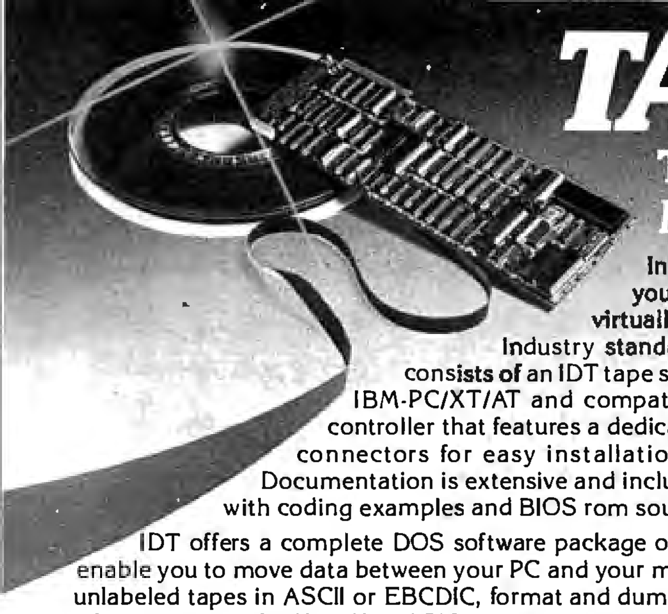

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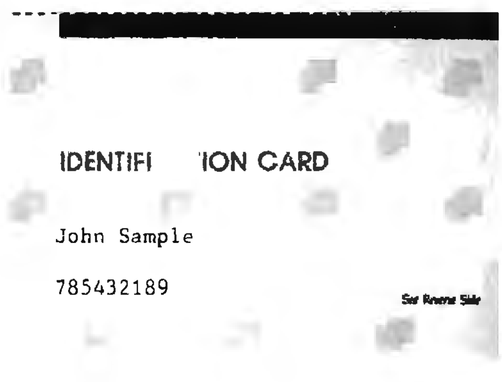

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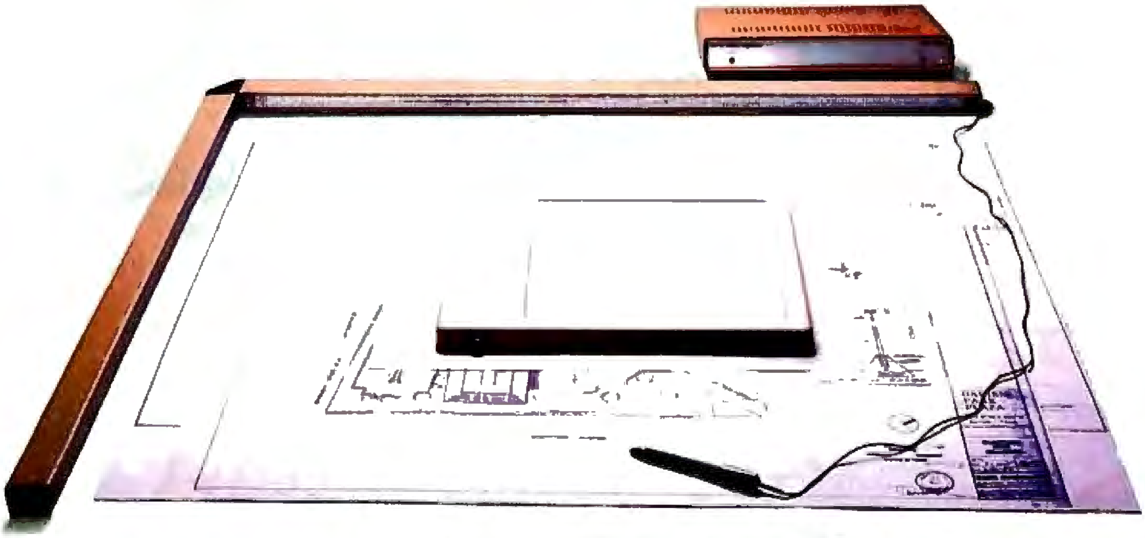

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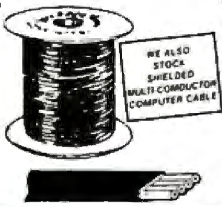

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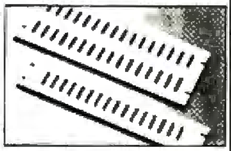

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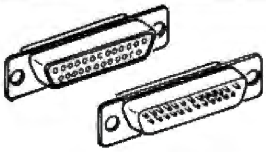

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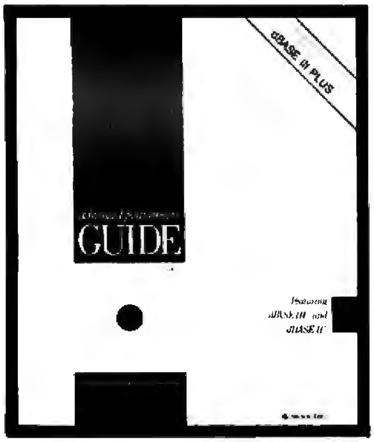

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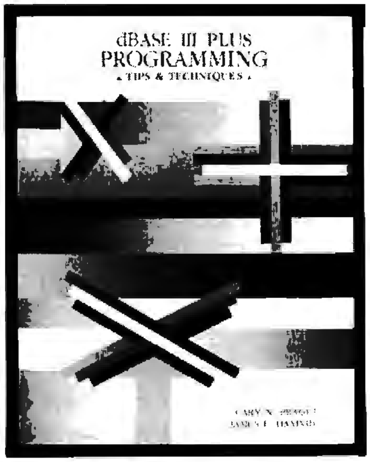

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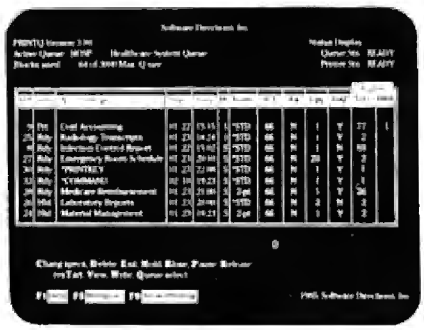

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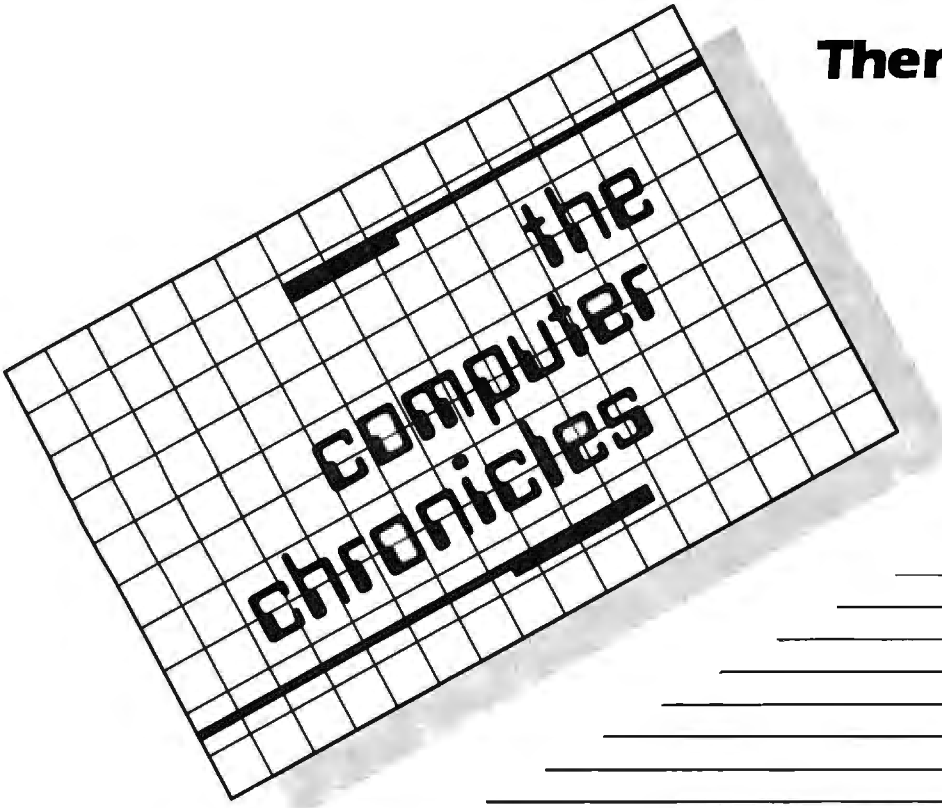

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AI, AI, Oh!

Ezra Shapiro

I was originally going to title this month's column "Mostly MS-DOS" because two of the three products evaluated run on IBM PC-compatible machines, and I haven't been finding much of note in the DOS world to rave about recently. But the first package, VP-Expert, is classy enough to deserve its own headline. Maybe I'll use that "Mostly MS-DOS" head when I start getting tons of programs that take advantage of the real power of the Intel 80286 and 80386, but I'm not holding my breath.

VP-Expert is an inexpensive expert-system program that actually works

AI for Everyone

For a while there, if you bought an expert system development package, you had to have it delivered by armored truck; programs started at two grand a pop and went from there through the roof. The more expensive products threw in a week or two of training for your personal knowledge engineer, but that was little solace. You couldn't fool around with artificial intelligence unless you were a reviewer, a LISP or Prolog programmer, or a multimillionaire. True, AI techniques were incorporated into programs like Symantec's Q&A and Lotus Development's HAL, but you were kept pretty far away from the guts of the programs.

VP-Expert (Paperback Software, $99.95) strikes me as the first development package that has a chance to gain widespread public acceptance for microcomputer expert systems. The company has enough marketing and distribution muscle to get the product into circulation (muscle that earlier efforts have lacked), and VP-Expert is inexpensive enough to be purchased as an experiment. And it seems to be as powerful as competitive products costing thousands of dollars more.

So what exactly is an expert system? It's a collection of rules for analyzing data in much the same way a human expert would interpret it. An expert system is designed with a specific goal in mind, like diagnosing a malfunctioning computer or suggesting the appropriate wine to drink with dinner. You enter what you know about a problem, and the expert system matches your information against its rules. If it can guide you to a solution, it does so, but it's "smart" enough to ask for more pieces of the puzzle if what you've provided is incomplete or inconclusive. The rules are merely a list of logical operations of the IF . . . THEN . . . ELSE sort, but you can build an intricate tree out of simple syllogisms.

The heart of VP-Expert is a backward-chaining inference engine capable of 20 levels of recursion. In a run-time session, you give it the particulars of a situation. The program starts with the first variable you fed in and tests it against the rules to see if it can match its goal; if it reaches a dead end, it backs up and tries again with a new branch of rules. This process continues with each variable until the program reaches a conclusion.

VP-Expert is something between a programming language and an application. You develop your rules with what is essentially an abbreviated language, with reserved words, variables, block procedures, and even a semicolon at the end of every line. However, you don't have to worry about file handling, I/O, or the actual interface; in that regard, VP-Expert is a lot like dBASE. You've got a built-in editor (though you can write your code with a program editor or a word processor in nondocument mode), a debugger that drops you back to the offending line if it spots a syntax error, and several forms of program tracing. When you're executing an expert system, you can stop the engine and ask it why it's doing something, and it will display the rule in question. You can even have it prepare a visual display of the route it took to reach a conclusion, in either text or graphics.

The program interfaces nicely with VP-Planner, Paperback's spreadsheet, and VP-Info, the firm's database manager. VP-Expert can also make use of data files that follow either the .WKS (Lotus 1-2-3) or the .DBF (dBASE II or III) file format.

Therein lies much of VP-Expert's strength. If you can write generalized rules for your expert system, you can keep your specifics in a database or spreadsheet, thereby breaking your expert system into a "rule base" and a "knowledge base." When the expert data changes or grows, you don't have to worry about recoding your entire rule structure; you can just edit your database. And as VP-Expert itself can modify an external knowledge base, you can build a system that "learns": If you enter a set of conditions outside the program's experience, it can query you for more information and build the new case into its knowledge base.

VP-Expert gives you more latitude than one definite answer per question. "Plural variables" let the engine list all the possibilities that fit your query rather than stopping after it hits the first match in the knowledge base. You can also attach a "confidence factor" from 1 to 100 to any rule or variable, either in the expert system itself or as part of your run-time query. A high confidence factor indicates absolute certainty; the lower the factor, the less definite the conclusion.

VP-Expert will compute the overall confidence factor for any answer it generates, so you're not bound into a completely deterministic system. Although

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P.O. Box 170040, San Francisco, CA 94117. Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

If constructing an expert system from scratch strikes you as too much work, VP-Expert has a shortcut method of creating a rule base.

confidence factors are not true probabilities—they're merely a statistical representation of likelihood—you can get a good feel for the applicability of any answer the program derives.

If constructing an expert system from scratch strikes you as too much work, VP-Expert has a shortcut method of creating a rule base. You can develop a table of examples using the editor (or a program that generates pure ASCII, .DBF, or .WKS files) and have VP-Expert induce a set of rules from the data. You'll find that you have to edit the resulting rule base—to rephrase the questions the program asks the user at run time, format nice-looking menus, and so on—but you can avoid having to develop the basic logic.

The documentation that comes with VP-Expert is top-rate. I read 200 pages of it before loading the program for the first time, and I found it to be as good a tutorial as I've seen in a while. There's also a full command-by-command reference section that makes terrible reading but is extremely useful when you're trying to use the product. There are quite a few examples of small systems on the disk, keyed to the tutorial. If you want to see an example of a big system, the package's help program is nothing but an expert system developed with VP-Expert. You can dissect and modify it if you like.

That's about it for the product description. I spent a couple of weeks playing with VP-Expert, and it performed exactly as advertised. The interface was clean, and I had no trouble running the sample files and building little expert systems of my own. However, I had neither the time nor the presence of mind to construct a large expert system, which is the real test of a program like this. I suspect that the use of database and spreadsheet files will make large systems possible, and also rather quick, but I can't make that claim from personal experience.

I do wish Paperback had included even more examples on the disk and a section in the manual suggesting possible uses for the program. This is a class of software unfamiliar to me, and I would have appreciated more guidance. My only objection to the program is that many of the sample expert systems deal with food choices; I kept wanting to leave the computer and go fix myself a snack.

The $99.95 buys you a copy-protected disk; another $10 (plus a signed license agreement) gets an unprotected disk. If you develop an expert system you'd like to sell to the world, you can purchase unlimited distribution rights to a run-time version of VP-Expert for $500. Copies of the run-time program can be had for $10 to $4, depending on quantity, so you can run your expert system on several machines within your company. The run-time package includes an encryption utility, so nosy users can't mess with either your program or your data files; a welcome measure of security.

I am extremely curious to see what people do with this product. Will they construct expert front ends for traditional databases? Develop and market true expert systems? Or will they just let it gather dust on retailers' shelves? I have

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absolutely no idea. Is the world ready for low-cost AI? Time will tell.

Paint Wars

Well, I should have known. When I wrote in my February column that GraphicWorks and SuperPaint are complementary products that are both worthy successors to MacPaint, I had a sneaking hunch that they'd become head-to-head competitors eventually. Sure enough, the two products are now borrowing from each other like crazy. If this keeps up, they'll be identical before too long, and you'll have to base your decision on price and support rather than on features.

Right now, they're still leapfrogging each other—one package gets ahead for a few months, then a new version of the other jumps out in front. All this is happening so quickly that I doubt I'll be able to keep up, and my lead time is relatively short; I write these columns only about three months before they appear in print. So I'm hesitant to say anything extreme about my beta version of **GraphicWorks 1.1** (Mindscape, $79.95) because SuperPaint is bound to catch up soon.

I like version 1.1. As before, you get all the standard MacPaint features in an object-oriented environment. You can create your artwork piece by piece. When you overlay the pieces into a finished arrangement, you don't lose what's underneath the way you do with a bit-mapped paint program like MacPaint. You can reposition to your heart's content. There's that incredible variable airbrush tool, and overlaid objects can be masked in wonderful ways.

This release adds a long list of spiffy features to the product. You get the four precious ClickArt modification tools: free rotation (one of the biggest lacks in version 1.0), slant, perspective, and distort. You now get four palettes of patterns, including laser grays, Imagewriter II colors, and spaces for your own creations. GraphicWorks can import TIFF (Tag Image File Format) files from optical scanners and can edit at laser-printer resolution. Context-sensitive tool palettes change depending on the type of object you're manipulating, which ends a lot of confusion.

Nice rulers have been added, with sharp position arrows and a choice of dimensions. GraphicWorks can now import and export PICT data. Imported PICT files (like those from MacDraw) can be scaled but not edited; GraphicWorks objects exported via the clipboard move as PICT images rather than as bit maps, for cleaner scaling in their new home. A novel command lets you build objects as QuickDraw primitives; the major result of this is faster printing.

The product is faster than its predecessor, particularly with complicated documents. I no longer had the feeling that I was always ahead of the program. The high-resolution editing was easy to access and no problem to use, though I still get a bit lost trying to figure out appropriate scaling for printing to my QMS laser printer. Laser printing also seemed to be much quicker with this version. I still wish that the snap grid was more flexible and that it could be displayed in the painting areas instead of only on the background page, but the rulers are a big help for precision.

My favorite aspect of this package is still the airbrush, which can be set in 1-pixel increments from 1 to 96 pixels in diameter. The new contextual menus are quite good, and I had little trouble using the program even though they've added so many new features.

Once again, I'm impressed, but I cannot suppress the thought that this continuing quest for power is antithetical to the original purpose of MacPaint. MacPaint was limited, and hence very frustrating for the dedicated graphics professional, but it was intuitive, simple, and *fun*. It was the program you used to show off

continued

Items Discussed

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StarFixer $29.95
Hard/Soft Press
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Riverdale, NY 10471
(800) 222-9409 (orders only)

SuperPaint $99
Silicon Beach Software Inc.
9580 Black Mountain Rd., Suite E
San Diego, CA 92126
(619) 695-6956

VP-Expert $99.95
Paperback Software International
2830 Ninth St.
Berkeley, CA 94710
(415) 644-2116

your Mac, and you could learn to use it in 10 minutes. GraphicWorks is getting to be a heavy-duty tool. That's fine if you're serious about your art, but what if you just want to have a good time? Maybe its designers should take a long look at Microsoft Word's "short menu" mode and see if they could give GraphicWorks a two-level interface, so that Mac graphics could again be fun for the rest of us.

WordStar Forever

WordStar 4.0 is supposed to arrive any day now, and I'm hoping I'll like it. The announced list of features is long and commendable, so I've got my fingers crossed. However, if it isn't up to snuff, I've got my answer.

I'm having a delightful time with **StarFixer** (Hard/Soft Press, $29.95 plus $2 for postage), which I nominate as the best utility product ever for WordStar 3.3x. I admit those are pretty strong words, but this collection of programs is brilliant, even if the concept is so obvious that you'll wonder why nobody ever thought of it before.

Every grizzled WordStar user has had to sweat through MicroPro's installation program. It takes forever, and when you're done, the Backspace and Delete keys still don't work correctly. Either you heave a resigned sigh and live with WordStar's oddities, or you learn about patching the program with a debugger (I include in this the "secret" patching commands within the installation program). Ever since MicroPro stopped giving away its technical reference notes as a freebie, WordStar patchers-to-be have had to scour the bulletin boards for tip sheets on the program's internals. The whole process could be a nightmare.

Those days are gone. StarFixer is a patching program that lets you modify almost anything you'd care to change in WordStar. What's more, it looks like WordStar, and most of its commands are similar to those of WordStar. When you enter a command, StarFixer patches your WS.COM. You proceed through the program as if you were preparing to edit a document: setting the margins, line spacing, and tabs; changing the help level; and so on. Only you're changing the defaults within WordStar itself. If you can use WordStar, you can use StarFixer.

You can also do something about WordStar's annoyances, like the Backspace/Delete problem, the length of time it takes to display menus and warnings on the screen, and that obnoxious sign-on message. A companion program, KeyFixer, lets you reconfigure your function keys and the numeric keypad and even add 10 shifted function keys. Other goodies in the package include batch files that will run Debug and install WordStar for a 42- or 43-line display on an enhanced graphics adapter monitor and RescueWS, a program that will grab an accidentally abandoned file out of memory after you've exited from WordStar.

These programs don't do everything (Did you know that it used to be a 1-byte patch to change WordStar from an MS-DOS to a CP/M-86 program?), but they come pretty darn close. And let's not forget the documentation, which is a treat to read even if you have no interest in running the utilities.

Steve Manes and Paul Somerson, who wrote StarFixer, are becoming the gurus of WordStar. As Ward Starr and Mel Murch, they were the authors of the wonderful *Underground WordStar*, a compendium of tips, tricks, and folk wisdom about their favorite word processor. When you buy StarFixer, they throw in an expanded revision of that classic. Its breezy, irreverent style should serve as a lesson to the authors of all computer documentation.

Do I like this program? Take a wild guess. ■

Every month, BIX users (also known as BIXen), leave thousands of messages on BIX. These messages ask and answer questions, solve problems, and express often strongly held opinions. The Best of BIX is a look at some of the most interesting messages. This month's contributions come from the Macintosh, Amiga, and Atari conferences. If you'd like to join the BIX community, see the advertisement on page 337.

MACINTOSH

Not surprisingly, Apple's introduction of the Macintosh SE and the Macintosh II has generated some lively discussion on BIX. The following threads include comments from BYTE Technical Editor Tom Thompson (coauthor of the SE/II preview in the April BYTE). Author Larry Loeb is writing a review of the SE, which will appear in a future issue. Here, you'll see his initial reactions after receiving the SE for review. There's a lively discussion of why the SE doesn't use a 68020 processor, plus questions and answers about Mac II memory expansion.

MACINTOSH SE, FIRST REACTIONS

macintosh/mac.se #2, from tom_thompson (Tom Thompson, BYTE Magazine), Tue Mar 3 08:37:27 1987.

We were able to acquire a Mac SE so that we could handle questions concerning it. We've had a day to examine it before sending it out for a thorough evaluation by Larry Loeb. Here's what we can report so far:

1) If you're going to get one of these puppies, MAKE SURE YOU ORDER A KEYBOARD. Apple has unbundled the keyboard from the machine, so you can pick from two types of keyboards. A good idea, but somebody should make sure you at least get a keyboard, because our SE arrived without one. Since the SE gets its keyboard I/O through the Apple Desktop Bus, using a regular Mac keyboard is out. To be fair, it might have been a logistics snag. Apple did Fed Ex us one that arrived the next day. It doesn't seem as solid as the old Mac keyboards. I'm a keyboard "banger" (as opposed to a typist), and I'm afraid some day this thing might cave in on me.

2) Using "Get Information," I obtained the following version numbers for the system files:

System - 4.0
Finder - 5.4
Scrapbook - 2.1
Imagewriter driver - 2.5
LaserWriter driver - 3.3
Laser Prep - 3.3

3) The control panel devices are broken down into separate units that the control panel summons up, apparently to provide device independence in future machines. There was no 16-MHz option anywhere in the control panel settings.

4) You now have a Restart and Shutdown option in the special menu on the Finder. Restart is the old shutdown option (the machine reboots) and Shutdown preps the machine for powering down (closes files, etc.). Activating Shutdown blacks the screen, and you get a dialog box stating that the machine can safely be turned off.

5) The cooling fan sounds louder than I remembered during the Apple visits, but my memory. . .

6) Beepinit works OK with the SE. I installed the Road Runner "beeps" as the SysBeep with no problem. It's got a 68000, so things should be compatible, but remember the size of the ROMs has doubled.

macintosh/mac.se #3, from lloeb (Larry Loeb), Tue Mar 3 09:56:50 1987. A comment to message 2.

The mouse is different, too. It slopes down to the cord and isn't as boxy as the standard Mac mouse.

Sucking an 800K disk onto the hard disk took under 2 minutes.

I'm NOT giving it back.

macintosh/mac.se #4, from jamurphy (Joe Murphy), Tue Mar 3 12:06:32 1987. A comment to message 3.

Some questions. . .

A) It has a straight 7.8-MHz 68000, correct?

B) Does it still have the external drive connector? If so, does that mean more than two floppy drives are supported?

C) Is there an external jack for video, or is that only supported through the expansion card? (You need a card for an external monitor.) If so, will we see color video boards for the Mac SE?

D) Finally, if the clock is on the motherboard and will last 7 years, does that mean there is no way to replace it? Are they saying that in 7 years nobody will be using the Mac SE? (In other words, that this machine has a 7-year life span?)

The Mac 512KE is gone, what about the Mac Plus? Its days are definitely numbered.

macintosh/mac.se #5, from lloeb, Tue Mar 3 12:14:44 1987. A comment to message 4.

1) Yes.

2) The external disk drive connector is there. Dunno about supporting more than two drives, though.

3) No external video output.

4) Dealer will have to unsolder and DISPOSE of the lithium battery, which is considered hazardous waste material.

5) I have a functional Plus (hacked Mac, 1 meg with fan). I don't see its days numbered at all. I think there will be a lot of 512K-to-1-meg upgrading going on as the software that won't run on the 512K becomes more prevalent.

continued

macintosh/mac.se #7, from frankb (Frank Boosman), Tue Mar 3 12:59:01 1987. A comment to message 4.

The Macintosh 512KE is not gone. It is still being sold, and at the same price as before the announcements. The Macintosh Plus is still around, too, and again at the same price.

It's very possible that Apple might drop the 512KE this year, but they seem committed to the Plus remaining as an entry-level Macintosh.

macintosh/mac.se #8, from reviews6 (Joel West), Tue Mar 3 13:47:46 1987. A comment to message 7.

They have to keep the Plus, and probably the 512KE as long as they sell. Since they don't have clones to help them out, they must keep the entry-level buy-in price low, to allow universities and individuals to be able to buy SOMETHING, even if the price is less than optimal.

I think, having seen their announcement, that the Plus will remain until Apple decides to drop the price of the SE down into the Plus's range and use it as the entry-level machine. I don't expect a big glut of Pluses on the market - particularly with Apple's new SIMM (Single Inline Memory Module) memory upgrade - since they can be expanded using SCSI peripherals, and because everyone now needs an extra Plus around the office to be a fileserver.

I agree, the 512KE's days are numbered, but as long as they sell, Apple might as well continue to amortize their original Mac (128) tooling investment. Their main goals for 1987 would seem to be:

1. Standardize the 800K/HFS media.
2. Standardize the 128K ROM.
3. Standardize a new System (probably 4.1).
4. Ensure that all software runs on the new machines.

The 512KE doesn't hurt them, since it can meet 1, 2, and 3, and the lack of SCSI should be transparent to applications. 512K is still enough to do useful work, although MPW 2.0 will probably require a Plus or bigger.

Finally, in case you missed it, all Pluses are now shipping in gray, but I believe (I haven't seen one) the 512KE remains in beige. I think that says something about long-term plans.

MORE REACTIONS FROM THE REVIEWER

macintosh/mac.se #19, from lloeb, Wed Mar 4 13:05:00 1987.

It's been 24 hours since I ripped open the box. Time enough to look up and say "Is it good for you, too?"

It's a good thing Apple does not bundle the keyboard with the SE, because the one they sell now is not - ummmm - to my taste. (Sounds better than "It rots!" - no?) The space bar is too short, there's not enough tactile feedback on the keys. I keep mashing them into the circuit board without trying. Needs to be stiffer.

For the last year, my idea of a wonderful system was a Plus with an internal MicahDrive. It was fast, furious, and didn't bomb. Which, given the then-state-of-the-SCSI Manager, was a wondrous thing. The guy who did the software for that drive was sometime-BIXer Steve Brecher. The point is that the HD 20 SCSI in this beast works as fast as that. Apple has cleaned up the SCSI, true. But the elegance of how the drive is integrated into the rest of the system shows art. I wonder if Steve Wozniak did the drivers?

I still don't know what the Control key (not Open-Apple/CMD/Cloverleaf) does. KeyCaps isn't much help there. Matter of fact, there's this big arrow key on the top for Reset that doesn't make sense to me either. I think it works on the ADB stuff.

It's noisy. Steve Jobs wasn't totally wrong on this one **folks**. My machine has a system-saver fan on it that lets you know it's there, but it's unobtrusive. This one sounds like the noise the rocket ships make on Buster Crabbe-vintage Buck Rogers serials. Sort of a droning buzz that is starting to annoy me.

Nothing from the Loeb Archives has crashed on it so far with the exception of Psion chess. I'm still checking why. Maybe it needs its own system with it or a custom resource.

The guided tour that comes with it is cute, using the MacroMind Tour engine. Great for that in-store demo, as it subtly shows off with animation and sound what the Mac concepts are. Should make a lot of novices look at a character-generated screen and say, "Why can't *that* one do what the Mac can?"

The 4.0 system seems rock solid. My favorite TMON tricks won't crash it. 4.0 was sent to developers in the last week (my copy was mangled; this happen to anyone else?), and 4.1 will show up with the II. We will THEN have a universal installation disk for all machines. I guess the Installer scripts will selectively patch and install for a specific machine. As supplied now, it's over 400K (!), so 800K drives are recommended before use.

68020 DEBATE

macintosh/mac.se #36, from rpierrehumbert \ (Raymond Pierrehumbert), Mon Mar 9 23:31:34 1987.

Why, oh why didn't Apple put a 68020 in there? The new expandability of the SE is okay for those of us using the Mac for floating-point number crunching, since it at least allows the addition of a coprocessor, but the 68000 will never come close to the power of the 68020 (and it doesn't work as gracefully with its coprocessor, either). Given the numerous cheap 68020 upgrades to the Mac Plus that claim backward compatibility (e.g., the Novy Systems board), it seems like it wouldn't have been so hard for the SE to have been designed around a 68020. Sure, the Mac II has a 68020, but it's expensive, big, and not portable. Has Apple forgotten the rest of us?

macintosh/mac.se #37, from lloeb, Tue Mar 10 09:07:53 1987. A comment to message 36.

No, they are leaving that niche for the third-party people like Levco. They are going to have enough headaches (Apple, that is) just supporting the II.

macintosh/mac.se #40, from reviews6, Tue Mar 10 13:19:56 1987. A comment to message 37.

Everyone keeps complaining, "Why isn't an SE a Macintosh II?"

Give me a break. Do you put a 302 Hemi in a Chevette? If you want to go fast, Chevrolet will gladly sell you a Camaro or a Corvette. If you want luxury, their sister division has many different Cadillacs to choose from. If you want something small and cheap, you don't get fast.

I don't like the price of the Macintosh II (as someone who has to pay for one). But because of the 68020's power and additional costs, a 68020-based machine will be a high-end product for at least 2 years, more expensive by at least $1K than a 68000 box. And if I'm going to have that kind of horsepower, I might as well shell out the additional $500-$1K for the expandability so I can extend the life of the machine indefinitely, add new peripherals, and so on.

continued

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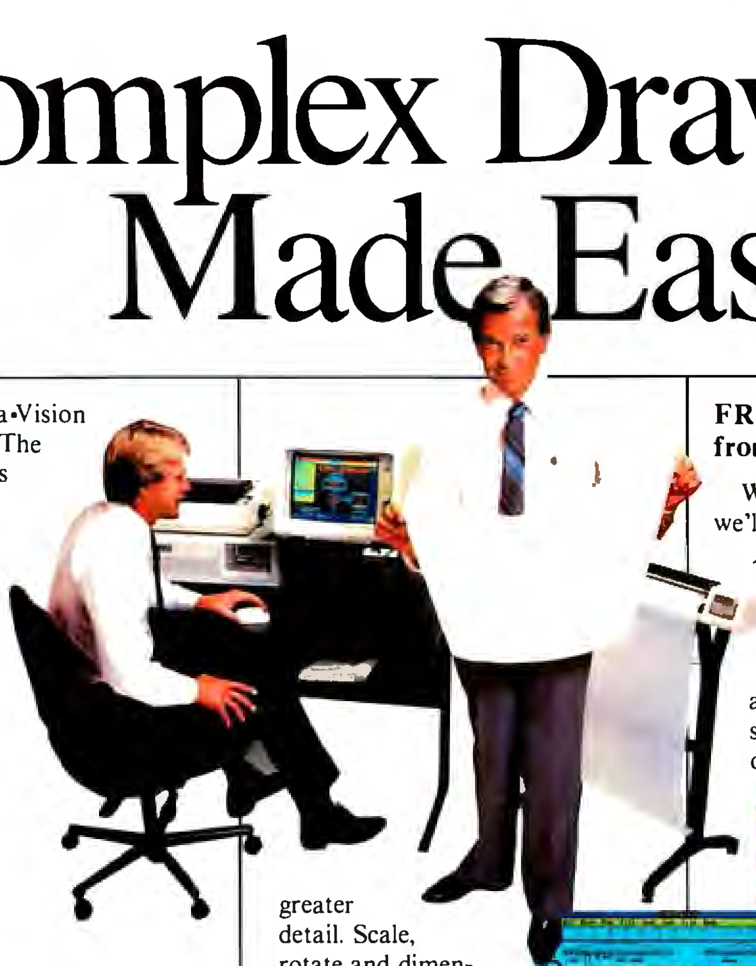

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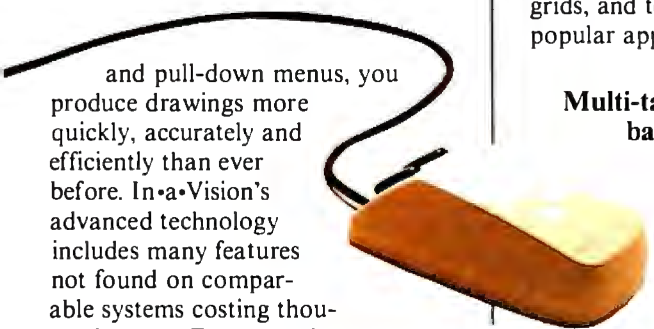

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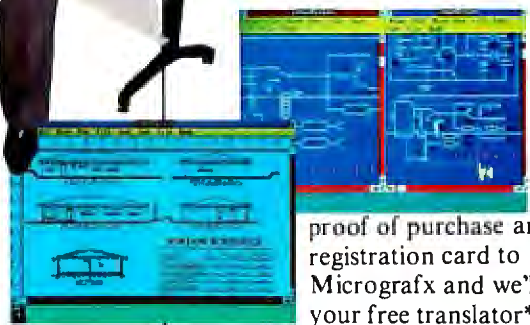

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The SE is the size it is because they wanted to keep a similar form factor; hence, one slot. If I had an SE, I would be torn between a 68020 board, a large-screen display, or IBM compatibility (8086 + floppy controller), so, clearly, one slot is not enough for long.

---

macintosh/mac.se #42, from tom_thompson, Tue Mar 10 16:49:36 1987. A comment to message 40.

My current feelings about the SE:

If you've already got a Mac, upgrade it as far as you can take it (to a Plus).

If you don't own a Mac, and have the bucks, get an SE. It has the better power supply, the slot, the improved bus bandwidth, and–most important–a better SCSI interface.

If you've really got to have the power of the Mac II, then money will be no object and you'll get the Mac II anyway.

This is *not* to knock the Mac SE (right, Larry?). See the don't-own-a-Mac statement above for confirmation.

---

macintosh/mac.se #43, from lloeb, Tue Mar 10 17:39:01 1987. A comment to message 42.

If you want most of a II without the color and limited expansion, but cheaper, get an SE and an accelerator board. And an internal hard disk.

---

macintosh/mac.se #44, from alf (Eric Klein), Tue Mar 10 20:08:46 1987. A comment to message 40.

I agree that it would have been ridiculous to have put the 68020 in both machines. If both machines had the 68020 chip, there really wouldn't be any big differences between the machines, except that one computer had one slot and the other had six. But Apple should have put a 12-MHz 68000 chip in the SE. This would help differentiate it from the Plus. Instead, Mac Plus sales will rapidly fade away because the main difference between the two machines is that one has no slots and the other has one slot. I don't understand why Apple underpowered the SE, unless they are trying to get us to spend the extra money on the II. (If this is their strategy, then I must admit that it will work over the long run.)

---

macintosh/mac.se #45, from lloeb, Tue Mar 10 20:37:29 1987. A comment to message 44.

A 12-MHz 68000 (or for that matter any clock cycle other then the standard one) probably would mean some current software wouldn't run. The clock speed on the SE *is* different, BTW. That's one of the ways they get the 75 percent CPU cycle, but they divide it down differently to get the standard Mac clock.

I think Apple wants to sell a lot of SEs to those people who are starting to think seriously about Macs in business and haven't bought Pluses. They can get a faster box and expand to MS-DOS through the port (and get those SEs *bought* by companies or institutions that have an MS-DOS fixation) while retaining Mac ease of use.

Scully has called the SE a "trojan computer." (One is tempted to make jokes about market penetration. . .) It will be easier for these machines to come in the front door of an MS-DOS shop.

---

macintosh/mac.se #46, from reviews6, Tue Mar 10 22:23:19 1987. A comment to message 44.

Everything I've seen suggests that Apple wanted the SE to be as compatible as possible. (Does it run Dark Castles? That indicates whether it has the alternate screen buffer.) This allows them to introduce new technology and even kill the old machines without breaking everything in sight. After the HFS problems, Apple seems to be both pushing and pulling on compatibility. Pulling by desperately testing new machines with old software and building tons of compatibility kludges in the new machines just so badly written software will run. (Also, to be fair, a lot of software was written before Apple had done their job on documentation, like the book *Inside Macintosh* and the Tech Notes, so the odds were stacked against the developer getting anything right.)

They are pushing by taking many of those problems discovered by its room full of testers and telling us what not to do anymore. That big mailing in late February was great, containing many specific problem descriptions (rather than vague, holier-than-thou admonishments) that can only help in writing better software.

But, as Larry noted, a 12-MHz 68000 would have reduced the number of programs that ran. I think it was a very shrewd move by Apple. Their new big seller will be compatible with all the old software, so their customers will be happy, but there will be enough IIs out there that developers will hear about those incompatibilities quickly and loudly enough. (Those of us frustrated by slow compiles will probably be among the first to buy the IIs, thus the developer may break his own software first.)

After a year of 68020 compatibility patch releases and speed calibrations, Apple could introduce a 68020 (68010 or 12-MHz 68000) as their baseline machine, replacing the SE at MacWorld 1988 without breaking everything.

---

macintosh/mac.se #54, from nz_mhamel (Michael Hamel), Wed Mar 11 22:58:26 1987. A comment to message 46.

Er - what software wouldn't run at 12 MHz? And if it wouldn't, why does it work on the SE? I mean, Apple tells us to rely on software loops for timing, so are people doing this?

In my humble opinion, Apple should have made the 68000 in the SE run at, say (just off the top of my head), 11.7504 MHz.)

---

macintosh/mac.se #55, from reviews6, Thu Mar 12 01:48:45 1987. A comment to message 54.

I can't win at Dark Castles at 8 MHz, and I certainly couldn't at 12. Also, some dastardly copy-protection code is left.

Until Apple published a timing-loop calibration constant, the only way to do stuff smaller than 1/60 second (the Time Manager is buggy) was a DBA loop, which is directly proportional to the clock speed rather than clock time.

---

macintosh/mac.se #57, from tom_thompson, Thu Mar 12 08:30:31 1987. A comment to message 55.

Also, a number of hardware components, such as the Integrated Woz Machine and the video display, use the 8-MHz clock for their operations. Boosting the clock rate would break hardware as well as software. The same is true of the Mac II. It's no surprise that the clock rate is double the conventional Mac's clock rate and that there are a lot of divider circuits on the motherboard.

---

macintosh/mac.se #48, from lrozier (Laurence Rozier), Tue Mar 10 22:27:31 1987. A comment to message 44.

Given the current street pricing for the Plus, I don't think that the SE will swing a large percentage of sales away from the Plus for at least a year (at least in the L.A. area).

continued

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macintosh/mac.se #50, from tom__thompson, Wed Mar 11 10:22:36 1987. A comment to message 44.

The slot in the SE is *not* a NuBus slot (as is the case with the Mac II). Both the SE and the Mac slots use the same Eurocard C connector, but don't make the mistake of thinking they're electrically identical. Also, the card must lie flat in the bottom of the SE, while it stands upright in the II.

macintosh/mac.se #53, from ccrawfor (Chris Crawford), Wed Mar 11 21:19:27 1987. A comment to message 50.

At the SEF meeting the other night, somebody asked Scott Knaster what the technical designation for the bus on the SE is. Scott hardly blinked before shooting back, "Apple Macintosh SE Bus." There you have it, the official designation.

macintosh/mac.se #60, from rpierrehumbert \, Thu Mar 12 22:10:49 1987. A comment to message 44.

There is no good reason why a 68020 machine should cost that much more than a 68000 machine, since the chip price is such a small part of the total system cost. In short, the difference in price between a 68020 and a 68000 isn't much more than the difference between a turbo-charged Corvette engine and a Chevy V-6 (I say this not knowing anything much about car engines). Eric Klein's argument seems to be that Apple had to deliberately degrade the performance of the SE so that it would not compete with the II. I hope this is not what Apple is really doing to us. After all, Big Blue tried it with the PCjr (Let them eat chicklets!), and it didn't work.

macintosh/mac.se #38, from lrozier, Tue Mar 10 09:23:04 1987. A comment to message 36.

I've heard that Motorola wasn't ready to raise 68020 production to the level required for the SE. Price may also have been a factor, since the decision to go with the 68000 must have been made some time ago.

macintosh/mac.se #39, from lloeb, Tue Mar 10 10:42:38 1987. A comment to message 38.

Apple at one point shipped a machine to developers that was an SE with an 020 in it. Dunno if it was a marketing or technical decision, but Levco and others will give the SE owner the power of the 020/881 combo at probably a cheaper overall system price than a II.

macintosh/mac.se #58, from rpierrehumbert \ Thu Mar 12 22:03:09 1987. A comment to message 39.

But even if Levco can give you an 020/881 board to put in the SE, won't you be still limited by the 16-bit bus to memory and the basic 8-MHz clock?

macintosh/mac.se #59, from lloeb, Thu Mar 12 22:10:37 1987. A comment to message 58.

According to the Levco press release:

The 020 runs at 16 MHz and there is a 32-bit "internal memory-expansion bus for running additional high-speed memory modules, and a 16-bit I/O-expansion bus for connecting additional devices such as high-resolution monitors."

Looks like you get all the good stuff and none of the bad if you increase memory on the board rather than in the SE.

MACINTOSH II COLOR CAPABILITIES

macintosh/mac.ii #4, from cheath (Charlie Heath), Tue Mar 3 02:55:14 1987.

What *is* the color capability for the display card? I heard 16 colors. What are the color options? Are the color boards byte-per-pixel? What hardware blitting capabilities do they have?

macintosh/mac.ii #5, from tom__thompson, Tue Mar 3 08:13:30 1987. A comment to message 4.

The color card comes equipped with 256K bytes of memory giving it 4 bits per pixel (16 colors). You can expand this to 512K for 8 bits per pixel and 256 colors. If byte-per-pixel means "all color bits in one byte," the answer is yes (Apple calls this "chunked"). There's a special chip called the TFB that handles the display, but I don't know if you'd call it a blitter. The video-card documentation never mentioned blitting.

macintosh/mac.ii #6, from reviews6, Tue Mar 3. 12:47:26 1987 A comment to message 4.

The Macintosh II Video Card Expansion Kit, as listed, expands the standard display to support 256 colors instead of 16 colors.

And of course the number of colors is determined by the video card and the ability of the display to render those colors.

macintosh/mac.ii #7, from frankb, Tue Mar 3 13:04:53 1987. A comment to message 4.

There are no hardware blitting capabilities on the Macintosh II. Everything is still done in software. However, Apple has made it easy for third-party developers to integrate graphics coprocessors into their cards-especially the TMS 34010, upon which the II's transfer modes are based-and has stated in materials sent to developers that they themselves were working on such a product.

Of course, said graphics coprocessors would be invisible to the system and applications. No modifications to applications software would be needed.

MAC II MOTHERBOARD MEMORY

macintosh/mac.ii #14, from alf, Thu Mar 5 18:54:44 1987.

I read that a Mac II can hold 8 megabytes of memory on its motherboard. Does this translate to 32 megabytes of memory with megabit chips?

macintosh/mac.ii #15, from bvanantwerp, Thu Mar 5 19:59:35 1987. A comment to message 14.

I believe that is with 1-megabyte chips.

macintosh/mac.ii #16, from reviews6, Fri Mar 6 03:25:50 1987. A comment to message 15.

The announcement suggests that the II uses the same 1-megabit SIMMs as are available for the Plus & SE.

macintosh/mac.ii #17, from tom__thompson, Fri Mar 6 10:37:22 1987. A comment to message 16.

There are two banks of memory on the Mac II motherboard. Using 256K-DRAM chips, that's a total of 2Mb. (Note that the base Mac II configuration comes with only one bank populated, or 1Mb.) As the memory density increases over the years, you can add more memory to the Mac II motherboard, like so:

continued

1-Mbit chips --- 4Mb/8Mb where: memory bank 1/memory bank 2
4-Mbit chips --- 16Mb/32Mb
16-Mbit chips --- 64Mb/128Mb

Obviously, we don't have 4- or 16-Mbit chips yet, but the potential is there. Conceivably, you could add memory via NuBus, but then you've got to go through a number of additional bus cycles to access memory-meaning your best bet is to put it on the motherboard.

As an additional note, memory speeds on the new Macs have improved. To wit:

Old Mac and Mac Plus - 200-nsec memory
Mac SE - 150-nsec memory
Mac II - 120-nsec memory

Even with the faster memory, the Mac II uses two wait states for memory access: one wait state for address translation through the hardware memory mapper (HMMU) or 68851 (PMMU) and one wait state for memory.

---

macintosh/mac.ii #19, from nz_mhamel, Fri Mar 6 18:05:56 1987. A comment to message 17.

Interesting. Sun's 3-Series workstations get away with one wait state, I think. Also *my* Mac Plus seems to have 120-nsec chips in it. Nice to know they aren't needed. . .

---

macintosh/mac.ii #20, from alf, Fri Mar 6 19:07:56 1987. A comment to message 17.

How can you fit a 1-Mbit chip in the same spot that was meant for a 256K chip? I know it's possible, but I can't figure out how it's done. Also, it's interesting that the Mac II uses such slow memory. The memory in this Mac goes for $96.84 (at $2.69 apiece, assuming one chip per 256K for parity checking) without any quantity discounts. This is a very small amount of money compared to the high cost of this computer. At least 100-nsec chips should have been used; who needs wait states?

---

macintosh/mac.ii #21, from tom_thompson, Fri Mar 6 19:47:48 1987. A comment to message 20.

As I understood it, the only way to eliminate the wait state was to use something with a 60-nsec access time. Shows how fast that 68020 is booking, doesn't it?

---

macintosh/mac.ii #24, from nz_mhamel, Sat Mar 7 18:09:27 1987. A comment to message 21.

It looks as though Apple is going for a conservative design, as usual. My 68020 book indicates you have around 120 nsec total from valid address to data wanted on a 16-MHz 68020. Add two wait states and that's 240 nsec. If the RAM takes 120, there's certainly plenty of time for memory management, buffer delays, etc. . .

The difference between five cycles to read memory (including the ROM, I presume?) and three cycles to fetch from the cache means there will be some incentive on this machine to keep those loops inside 64 longwords. Another job for the compiler writers, eh?

---

macintosh/mac.ii #34, from skraegeloh (Stefan Kraegloh), Tue Mar 10 17:52:05 1987. A comment to message 24.

Actually it's 115 nsec from Axx valid to data wanted. Unfortunately, that's not a very useful specification. If you use dynamic RAM, you've got to start the access by asserting /RAS. Which, of course, you can do only if you know when a cycle will start. So what you were really looking for is the time /AS valid to data wanted, which is 85 nsec worst case (at 16 MHz). But then /AS is *not* the only way to tell the "start of an external cycle" (hint, hint for those of you with a data book). In fact, I've built a 16-MHz 68020 card (for the VME bus) using 80-nsec dynamic RAMs and featuring *no wait states*. By the way, these RAMs (IMS2800) were developed by Inmos and are now manufactured by IMC. They are available down to 60-nsec access time! I've heard Compaq uses these RAMs in their 386 PC.

---

macintosh/mac.ii #35, from alf, Tue Mar 10 20:09:31 1987. A comment to message 34.

Actually, the Compaq 386 uses 100-nsec (static) RAMs, which is a little conservative. On the interesting side, guess what type of RAMs Compaq now uses in ALL their 80286-based machines? Also 100-nsec RAMs. Why Compaq uses the same speed RAMs in their 16-MHz 80386 machines as their 12-MHz 80286 machines beats me. But with their replacement of their 8-MHz 80286 machine line with 12-MHz machines (with no price increases) they have become the technological leader of the PC-compatible industry. So maybe they aren't so conservative after all.

ATARI

In the Atari section this month you'll find some thoughts on how widespread the use of hard disks is in the ST community. Then there's a discussion on upgrading 1040 RAM to 2 megabytes.

HARD DISK PREVALENCE

---

atari.st/main #1802, from davjon (David Jones), Thu Mar 5 21:16:26 1987.

Does anyone have any idea how many ST users out in the big wide world have hard disks? Is it worth making special provisions for them in software packages (aside from the usual copy-protection gripes)?

---

atari.st/main #1803, from sprung (Ron Sprunger), Thu Mar 5 22:28:20 1987. A comment to message 1802.

You might ask Supra how many they have out. I think they are becoming very popular - I have three. I was recently asked by a dentist friend to help him set up his ST, and he had a Supra 20-meg. I believe that any program that doesn't run conveniently on a hard disk will be in for a *lot* of criticism - these machines are powerful, and a substantial percentage of users will be on hard disks.

To be convenient on a hard disk, a program should be able to run from any directory while residing in any other directory. The user ought to have a way to tell the program where to look for its resources and where to put its results. In addition (and extremely important if used for serious purposes), if I execute it from e:\ron, and my wife executes it from f:\judy, we each ought to be able to exercise it on the files in our respective directories. I get royally griped with programs that dictate where resources and output go or that have a system specification for output. Output should go to the current directory, but provision should be made for system specification, if desired by the user.

---

atari.st/main #1805, from tsikes (Terry Sikes), Fri Mar 6 04:49:05 1987. A comment to message 1802.

I don't have a figure, but it seems to me that as hard disk prices go down and the ST is viewed more as a serious machine, many more people will have them. Supporting hard disks should be straightforward as far as software development goes, except

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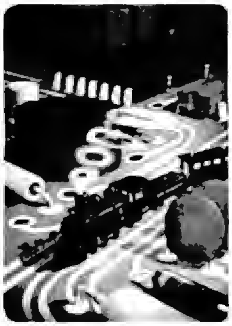

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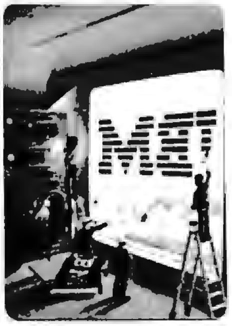

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1040 MEMORY UPGRADE

atari.st/main #1918, from jimomura (Jim Omura), Tue Mar 17 18:46:59 1987.

Has anybody upgraded a 1040ST to 2 megs? I'm starting to feel a need for a 2-meg machine.

atari.st/main #1921, from wes.peters (Wes Peters), Wed Mar 18 05:13:57 1987. A comment to message 1918.

Two megs is a little tricky to do. The machine (actually the MMU) is set up to address 1 or 2 banks of 256K-bit or 1-megabit chips. You could easily do 2 megs on a 520ST by switching to 1-megabit chips, but to do 2 megs on a 1040 (or any >1-megabyte configuration using 256K chips) would involve grabbing individual bits off the chip address lines when either RAS or CAS is strobed (while storing the lower bits in a FIFO), using the high-bit lines to select one of several banks of 256K chips, and *then* generating your own strobes while latching the stored addresses on the address line. Messy, very messy. On the other hand, if you replace your 256K chips in your 1040 with 1-megabit chips, which is fairly simple, you get 4 megs. . . . Neat, huh?

atari.st/main #1922, from jim_kent (Jim Kent), Wed Mar 18 11:57:09 1987. A comment to message 1921.

Do you have to do any software fixes for the 1040 to recognize the 4 megs?

atari.st/main #1923, from jimomura, Wed Mar 18 12:13:49 1987. A comment to message 1921.

OK, anybody got a part number for the 1-meg chips? Also, any other jumpering or trace cutting, etc.?

atari.st/main #1924, from alexl. (Alex Leavens), Wed Mar 18 16:26:23 1987. A comment to message 1923.

1) No software changes are necessary; the machine will recognize the 4 megs automatically. 2) 1-meg chips have a different pin-out and 2 more pions than 256K chips do, so you'll have to do a *lot* of work to upgrade.

atari.st/main #1926, from wes.peters, Thu Mar 19 04:29:31 1987. A comment to message 1923.

Yeah, 411M believe it or not. . . . try Microprocessors Unlimited; I think they advertise in BYTE and I know they do in *The Computer Shopper*. As Alex mentioned, the 1-megabit chips have more pins and a different pattern than the 41256s, so you'll have to create a daughterboard to hold the new chips. Other than that, it should just be a matter of bringing the extra address line and the extra (unused) RAS and CAS signals from the MMU. I haven't looked at loading resistors for this yet, so don't run off and try it unless you have a real competent digital engineer or a disposable ST handy.

AMIGA

The highlights of this month's Amiga conference begin with an extensive discussion on the accuracy of timing on the Amiga. From there a BIXer receives help on a "crashing CloseWindow" problem. We finish up with some thoughts on task priorities under AmigaDOS.

TIMER GRANULARITY

amiga/softw.devlpmt #3904, from tjeffries (Tom Jeffries), Sat Mar 7 02:02:34 1987.

There was some discussion here several months ago about the granularity of timing on the Amiga. (Actually, if I remember right, the discussion was on hardware, but bear with me; I have a software question.) The company I work for is considering porting its main program to the Amiga but was concerned because it looked difficult to get timing more accurate than 16 milliseconds, and we need accuracy to about 1 millisecond.

I have two questions: Someone did come up with a solution based on using the timer, but it looked as though you couldn't use the blitter and that timer at the same time. Does ordinary text require the blitter? In other words, can a non-graphics-intensive application take over the timer that the blitter uses? (I think it was timer B, but I'd have to look it up.)

Second, I just ran across a reference in some code that seems to indicate that the "SendIO(&timerio)" routine accepts arguments in seconds and microseconds. Does that mean I could get timing accurate to some number of microseconds (obviously, less than 1000 microseconds), or is it just an overambitious structure element name?

amiga/softw.devlpmt #3905, from cheath (Charlie Heath), Sat Mar 7 02:19:25 1987. A comment to message 3904.

Normal text would use the blitter, and it can chomp considerable amounts of time even if you have another task running at a higher priority, once the text has started. I recently had to get a program running with a 50-microsecond window of accuracy, and I couldn't do it without disabling interrupts during the timed intervals. For 1-millisecond accuracy, you probably would not have to disable interrupts, but you might have to do some tricks. Does the text absolutely have to be displayed while the timing is active? How much processing occurs at the 1-millisecond intervals?

amiga/softw.devlpmt #3907, from tjeffries, Sat Mar 7 13:20:18 1987. A comment to message 3905.

I don't need lots of processing, I just need to keep track, in 1-millisecond increments with a reasonable degree of accuracy. Could I use the timer that the blitter uses? Hmmm. . . if I understand what you are saying, it sounds like I would have to avoid large amounts of text being written. Do you have any idea how long it takes to write a single character to the screen?

amiga/softw.devlpmt #3910, from cheath, Sat Mar 7 17:20:10 1987. A comment to message 3907.

Text speed for single-character I/O is roughly 3 ms per character with standard text routines and roughly 1 ms per character with FastFonts installed.

If all you need is an accurate accounting of time, you can get that down to a resolution of a few microseconds using the vertical-blank counter registers. It takes a bit of calculation to get that into time format, maybe 20 microseconds of conversion in assembler. You'd also need a VBlank interrupt handler - they're pretty easy to install with RKM documentation.

amiga/softw.devlpmt #3911, from tjeffries, Sat Mar 7 17:30:32 1987. A comment to message 3910.

Thanks cheath, that's exactly what I need. BTW, why so slow printing text to the screen? The 68000 alone can do a lot of work in 1 millisecond; I would have expected the blitter to make things even faster.

continued

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amiga/softw.devlpmt #3912, from cheath, Sat Mar 7 20:23:40 1987. A comment to message 3911.

The main problem is that there is a lot of setup to work in layers, and setup for the blitter. The setup is the same whether you do one character at a time or if you do a whole line of 80 characters. If you set up your own display screen and manage it with your own direct-to-screen text routines, you could probably do single-character I/O about 50 times as fast, maybe more if you really get pushy. Note that the 3-millisecond time is for straight text rendering - if you go through the console.device, it'll be a bit slower!

amiga/softw.devlpmt #3913, from tjeffries, Sat Mar 7 21:25:35 1987. A comment to message 3912.

That's more in line with what I would expect: 50 times faster for a direct-to-screen routine. Ah, well, the advantages of modern technology. The info you've given me looks good in terms of getting project approval from the higher-ups. Most likely you're going to have to put up with still another programmer asking umptillion questions as I learn the Amiga!

amiga/softw.devlpmt #3906, from grr (George Robbins, Commodore Business Machines), Sat Mar 7 03:48:30 1987. A comment to message 3904.

Did you just need to measure elapsed time or to cause an event to happen at a precise instant? If the latter, do you need to perform any functions between the reference event and the next event or just wait for it to happen?

amiga/softw.devlpmt #3908, from tjeffries, Sat Mar 7 13:24:48 1987. A comment to message 3906.

It would suffice to have an accurate measure of elapsed time kept in a variable someplace. It would also work to have an event happen at a precise instant, but, yes, there would be other things happening in the meantime. With less fancy operating systems we've just set up a little interrupt routine, but I'm not sure how to do that on the Amiga without getting into trouble. There's probably a way, and I'm hoping somebody here has figured it out. Thanks.

amiga/softw.devlpmt #3909, from grr, Sat Mar 7 16:02:39 1987. A comment to message 3908.

Each 8520 has a "time of day" binary counter. One runs off a nominal 60-Hz tick signal, the other runs off the 15+ kHz horizontal frequency. It is possible that you could read the second 8520, but I'm not sure how it is set up and whether it free runs or the software messes with it. . .

CRASHING CLOSEWINDOW

amiga/softw.devlpmt #3914, from cmcmanis (Charles McManis), Sat Mar 7 21:41:11 1987.

I have a mysterious one: Every so often my code crashes when it calls the CloseWindow( ) routine. The window is a vanilla Intuition window with about 12 gadgets in it. I do play with the gadget list a bit, but everything is stable when I go to close the window. And it doesn't happen all the time! (Especially when my diagnostics are spitting things to the screen or printer).

Late news from Usenet: *DO NOT USE Delay(0)* in your programs. It can cause the disk activity going on in other tasks to get confused. A couple of people have trashed disks with the Hanoi program and the 2.05m version of Matt's shell.

Back to the window problem, when it crashes the Guru is an 810. . .5. in my code, backtraced to the CloseWindow( ) call, which claims the free list is corrupt. Since I have a version of Snoop built into my program, I know that it didn't free anything untoward. Of course, it is right after a FreeRemember call (my stuff), so maybe the FreeRemember routine returns before EXEC has freed all of the memory? Sorry for the rambling, but this is like the *last* bug and it is making me crazy!

amiga/softw.devlpmt #3915, from cheath, Sun Mar 8 00:13:59 1987. A comment to message 3914.

Most likely something got corrupted before, and it's just the CloseWindow( ) call that springs the trap. Hard to guess what, but since you say you do a lot with gadgets, that sounds like a good place to start looking.

amiga/softw.devlpmt #3918, from cscheppner (Carolyn Scheppner, Commodore Business Machines), Tue Mar 10 11:39:18 1987. A comment to message 3915.

I had a similar problem with my Palette program. Every time I ran it, Avail showed I had GAINED memory, and after several runs I'd guru with (I think) memory list corruption.

The problem was caused by deallocation of my dynamically created color chip gadgets PRIOR to CloseWindow( ). When I moved the deallocation after CloseWindow( ), the problem disappeared.

amiga/softw.devlpmt #3919, from cmcmanis, Tue Mar 10 14:07:53 1987. A comment to message 3918.

Does CloseWindow( ) try to deallocate Gadgets on the window's gadget list? I went back to the original Lattice 3.10 libraries and that seemed to cure it for me, but I am still not comfortable with the fix. I will try moving around the deallocates and the CloseWindow( ) call and see if that helps at all.

amiga/softw.devlpmt #3923, from cscheppner, Thu Mar 12 18:08:26 1987. A comment to message 3919.

CloseWindow( ) frees the system gadgets attached to the window. If you have some of your own gadgets added to the list, I imagine they had better be either Removed or valid when Intuition scans the list for system gadgets.

AMIGADOS SYSTEM TASK PRIORITIES

amiga/tech.talk #942, from tholloway (Tim Holloway), Thu Mar 5 22:44:56 1987.

Why are the system tasks in AmigaDOS at such low priorities? I'm running DACP and SPOOLer at priority 4, SPOOLprinter(s) at priority 3, and microEMACS as an ongoing task at priority 2. It's getting pretty crowded here. I'd think that having the DOS tasks at somewhere around 50 to 100 would be a lot better, and still leave room for animation and sound above them.

amiga/tech.talk #944, from cheath, Thu Mar 5 22:53:35 1987. A comment to message 942.

Can't you run at negative priority?

amiga/tech.talk #949, from jim_kent (Jim Kent), Fri Mar 6 19:09:39 1987. A comment to message 944.

Geez, I usually do animation at priority 0 to leave room for the sound and the disk. Don't want to lock out the root-block update of the disk for anything.

continued

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amiga/tech.talk #946, from lnoland (Les Noland), Fri Mar 6 02:39:44 1987. A comment to message 942.

I was very curious about the same thing. I would have suspected that the system tasks would all be at quite high priorities with a fair spread between those priorities chosen to allow for future system tasks. It really surprised me to find them crowded together with such low numbers. It shouldn't be too much trouble for user tasks, since it is now possible to set the priority of a CLI (and, correspondingly, that of processes launched from it) and negative numbers are available, though the lack of sufficient room between the system tasks (and the problem of tasks launched from the Workbench) might make things a bit tight for someone wanting to get creative with task priorities.

By the way, where is this SPOOLer of which you speak? Home grown?

---

amiga/tech.talk #948, from jdow (Joanne Dow), Fri Mar 6 12:53:15 1987. A comment to message 946.

print spooler == "run type <filename> to prt:"

---

amiga/tech.talk #950, from lnoland, Sat Mar 7 03:32:05 1987. A comment to message 948.

Not quite my idea of a print spooler. A print spooler should spool all printer output, regardless of source (e.g., any application that opens a printer file would have its output **spooled**). Sure would make life easier with some of these programs that demand to hang onto the printer whether they are using it or not.

---

amiga/tech.talk #955, from afinkel (Andy Finkel, Commodore Business Machines), Mon Mar 9 18:07:01 1987. A comment to message 948.

I posted a print spooler, based entirely on a CLI script a while ago. (I did it purely as an exercise, to see what the AmigaDOS scripts could do.)

---

amiga/tech.talk #956, from lnoland, Tue Mar 10 00:57:41 1987. A comment to message 955.

Yes, I've seen your print spooler but it still doesn't quite match my definition of a print spooler. It's useful, but not what I'm looking for.

---

amiga/tech.talk #966, from tholloway, Sat Mar 14 17:39:37 1987. A comment to message 956.

The Ami Project spooler is a true spooler. It consists of a spool-control program and one or more printer program tasks (that's right, one OR MORE!) Think of it as a mini-JES2, if you will. It maintains a set of queues to match idle printers to print requests, and vice versa.

---

amiga/tech.talk #963, from tholloway, Sat Mar 14 17:24:06 1987. A comment to message 946.

The default priority is zero. Supposedly, good little Amiga programs run between -5 and +5. Rather tight, even so. There's more room on the low side, since the only low-priority system tasks I know of are the validators, but the DEFAULT is zero, so dumb users (me included) are likely to get surprises if applications assume that somebody launched them at low priorities. The SPOOLer was covered in issue #4 (I think) of *Ami Project* magazine. Corrected and enhanced version (including source) is available on Casa Mi Amiga BBS at (904) 733-4515.

---

amiga/tech.talk #969, from lnoland, Sat Mar 14 20:14:04 1987. A comment to message 966.

Zounds! Time to place a call to the Casa Mi Amiga BBS, methinks! Thanks for the info on the spooler.

---

amiga/tech.talk #954, from afinkel, Mon Mar 9 18:05:20 1987. A comment to message 942.

If two tasks have the same priority, EXEC gives time slices in a round-robin manner. This eases things considerably. Also, the priorities could be changed in the future. (uh oh, I hear the sound of a worm can opening. . .) ■

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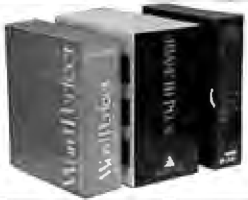

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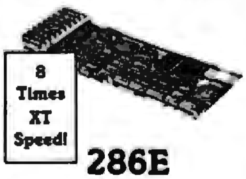

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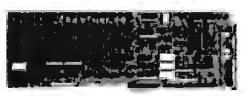

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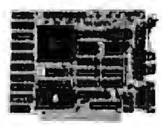

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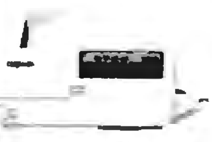

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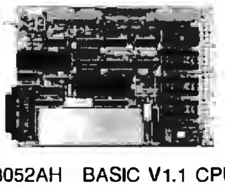

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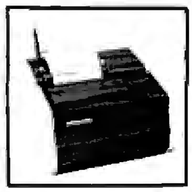

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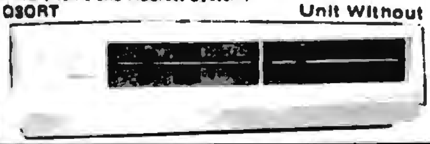

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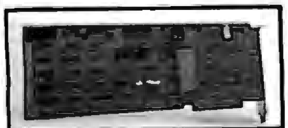

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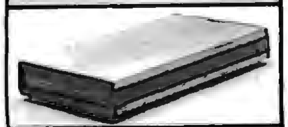

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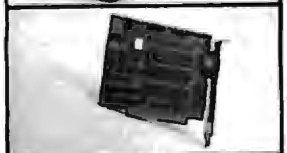

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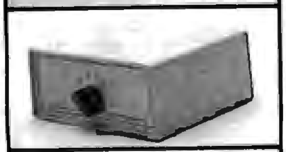

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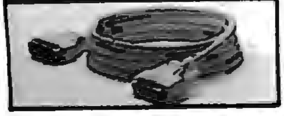

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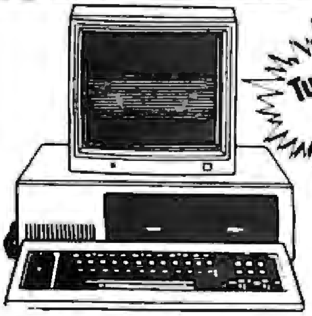

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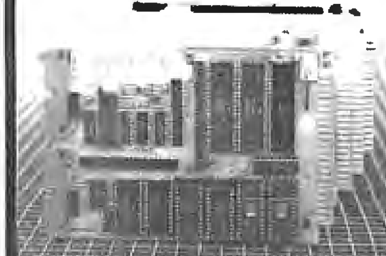

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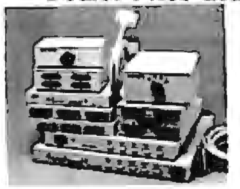

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Inquiry 304 for End-Users. Inquiry 305 for DEALERS ONLY.

The Amazing A-BUS

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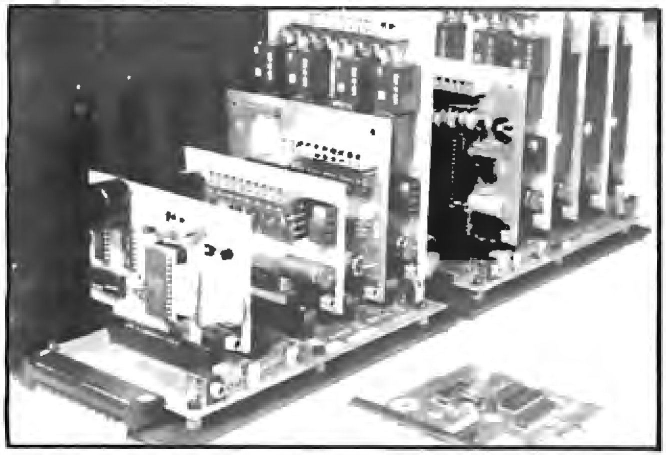


An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

Plug into the future

With the A-BUS you can plug your PC (IBM, Apple, TRS-80) into a future of exciting new applications in the of control, monitoring, automation, sensing, robotics, etc.

Alpha's modular A-BUS offers a proven method to build your "custom" system today. Tomorrow, when you are ready to take another step, you will be able to add more functions. This is ideal for first time experimenting and teaching.

A-BUS control can be entirely done in simple BASIC or Pascal, and no knowledge of electronics is required!

An A-BUS system consists of the A-BUS adapter plugged into your computer and a cable to connect the Adapter to 1 or 2 A-BUS cards. The same cable will also fit an A-BUS Motherboard for expansion up to 25 cards in any combination.

The A-BUS is backed by Alpha's continuing support (our 11th year, 50000 customers in over 60 countries).

The complete set of A-BUS User's Manuals is available for $10.

About the A-BUS:

- All the A-BUS cards are very easy to use with any language that can read or write to a Port or Memory. In BASIC, use INP and OUT (or PEEK and POKE with Apples and Tandy Color Computers)
- They are all compatible with each other. You can mix and match up to 25 cards to fit your application. Card addresses are easily set with jumpers.
- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples)

Relay Card — RE-140: $129

Includes eight industrial relays, (3 amp contacts. SPST) individually controlled and latched. 8 LED's show status Easy to use (OUT or POKE in BASIC). Card address is jumper selectable.

Reed Relay Card — RE-156: $99

Same features as above, but uses 8 Reed Relays to switch low level signals (20mA max). Use as a channel selector, solid state relay driver, etc.

Analog Input Card — AD-142: $129

Eight analog inputs. 0 to +5V range can be expanded to 100V by adding a resistor. 8 bit resolution (20mV). Conversion time 120us. Perfect to measure voltage, temperature, light levels, pressure, etc. Very easy to use.

12 Bit A/D Converter — AN-146: $139

This analog to digital converter is accurate to .025%. Input range is −4V to +4V. Resolution: 1 millivolt. The on board amplifier boosts signals up to 50 times to read microvolts. Conversion time is 130ms. Ideal for thermocouple, strain gauge, etc. 1 channel. (Expand to 8 channels using the RE-156 card).

Digital Input Card — IN-141: $59

The eight inputs are optically isolated, so it's safe and easy to connect any "on/off" devices, such as switches, thermostats, alarm loops, etc. to your computer. To read the eight inputs, simply use BASIC INP (or PEEK).

24 Line TTL I/O — DG-148: $65

Connect 24 input or output signals (switches or any TTL device) to your computer. The card can be set for: input, latched output, strobed output, strobed input, and/or bidirectional strobed I/O. Uses the 8255A chip.

Clock with Alarm — CL-144: $89

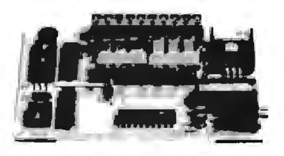
Powerful clock/calendar with: battery backup for Time, Date and Alarm setting (time and date); built in alarm relay, led and buzzer; timing to 1/100 second. Easy to use decimal format. Lithium battery included.

Touch Tone® Decoder — PH-145: $79

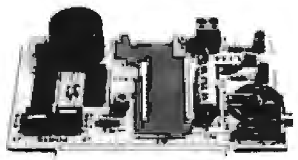
Each tone is converted into a number which is stored on the board. Simply read the number with INP or POKE. Use for remote control projects, etc.

A-BUS Prototyping Card — PR-152: $15

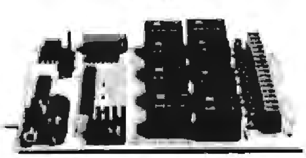
3½ by 4½ in. with power and ground bus. Fits up to 10 I.C.s



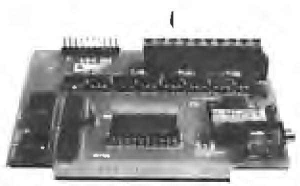
ST-143



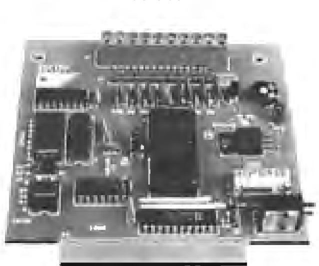
CL-144



RE-140



IN-141



AD-142

Smart Stepper Controller — SC-149: $299

World's finest stepper controller. On board microprocessor controls 4 motors simultaneously. Incredibly, it accepts plain English commands like "Move arm 10.2 inches left". Many complex sequences can be defined as "macros" and stored in the on board memory. For each axis, you can control: coordinate (relative or absolute), ramping, speed, step type (half, full, wave), scale factor, units, holding power, etc. Many inputs: 8 limit & "wait until" switches, panic button, etc. On the fly reporting of position, speed, etc. On board drivers (350mA) for small steppers (MO-103). Send for SC-149 flyer.

Remote Control Keypad Option — RC-121: $49
To control the 4 motors directly, and "teach" sequences of motions.

Power Driver Board Option — PD-123: $89
Boost controller drive to 5 amps per phase. For two motors (eight drivers).

Breakout Board Option — BB-122: $19
For easy connection of 2 motors. 3 ft. cable ends with screw terminal board.

Stepper Motor Driver — ST-143: $79

Stepper motors are the ultimate in motion control. The special package (below) includes everything you need to get familiar with them. Each card drives two stepper motors (12V, bidirectional, 4 phase, 350mA per phase).

Special Package: 2 motors (MO-103) + ST-143: **PA-181: $99**

Stepper Motors — MO-103: $15 or 4 for $39

Pancake type, 2¼" dia. ¼" shaft, 7.5°/step, 4 phase bidirectional, 300 step/sec, 12V, 36 ohm, bipolar, 5 oz-in torque, same as Airpax K82701-P2.

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Intelligent Voice Synthesizer, 14 Bit Analog to Digital converter, 4 Channel Digital to Analog converter, Counter Timer, Voice Recognition.

A-BUS Adapters for:

IBM PC, XT, AT and compatibles. Uses one short slot.	AR-133...$69
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TRS-80 Model 102, 200 Plugs into 40 pin "system bus"	AR-136...$69
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TRS-80 Model 4P. Includes extra cable. (50 pin bus is recessed).	AR-137...$62
TRS-80 Model I. Plugs into 40 pin I/O bus on KB or E/I.	AR-131...$39
Color Computers (Tandy). Fits ROM slot. Multipak, or Y-cable.	AR-138...$49

A-BUS Cable (3 ft, 50 cond.) — CA-163: $24

Connects the A-BUS adapter to one A-BUS card or to first Motherboard.

Special cable for two A-BUS cards: CA-162: $34

A-BUS Motherboard — MB-120: $99

Each Motherboard holds five A-BUS cards. A sixth connector allows a second Motherboard to be added to the first (with connecting cable CA-161: $12). Up to five Motherboards can be joined this way to a single A-BUS adapter. Sturdy aluminum frame and card guides included.

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Inquiry 99

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 Inquiry 94

California Digital

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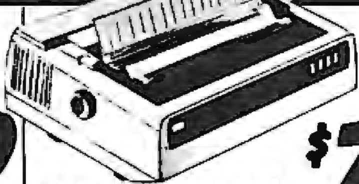
FOUR PEN COLOR PLOTTER $159

The manufacturer has asked us not to publish their name. But this four color plotter was produced by one of the Worlds largest makers of computers.
The 410 color plotter will connect to the **serial port** of virtually any micro-computer. Simple ASCII commands direct one of the four color pens to draw circles, arcs or ellipses on paper or transparency material up to 11 by 17 inches. The plotter is capable of producing the full upper and lower case alphabet along with seven international character sets. Text can be printed horizotal, vertical or diagonal in sizes from 1/16 to 6 inches.
Enlargements or reductions are achieved through elaborate firmware. Pen travel is four inches per second with .004" pen resolution. Standard pens are available in an assortment of 32 different colors and widths.
The ideal plotter for architecture, CAD engineering or graphic design. **At $595 it was a great buy, at $159 its a steal.** Support packages for specific computers available. Manual only $15 refundable upon purchase of plotter.

OTHER PLOTTERS AVAILABLE:
Hewlett Packard • Houston Instruments • Roland Sweet P • CalComp... please call for prices.



~~$2495~~

80 Character Daisy Wheel Printer $759

These Fujitsu Daisy Max 830 were manufactured for Motorola's Computer Division. The purchase order was canceled and Fujitsu was forced to liquidate these 80 character per second daisy wheel printers at "fire sale" prices.
Features: bullet proof construction, serial RS-232 interface, Diablo 630 wheels and commands, programmable line spacing in increments of 1/96" and column spacing of 1/120". The printer is also capable of underscoring, bold overprint, shadow print, centers and justifies along with vector plotting.
Factory suggested price of the Daisy Max 830 was $2495, while supplies last California Digital is offering this liquidated special at only $759. Also available: tractor and sheet feeders.

COLOR GRAPHICS TERMINAL

~~$3995~~ **$659**

The Lear Siegler 7107 color graphics terminal is both DEC (VT-100 / VT-51) and Tektronix (4010/4014) compatible.
The terminal offers a palette of 4,096 colors with a resolution of 640 by 480 pixels on a 13 inch non-glare black screen.
Horizontal pan and image zoom, to 16 times original size, are standard features of this color graphics terminal.
The 7107 is the ideal terminal for CAD/CAM applications.

NOW YOUR COMPUTER CAN READ!!

Omni-Reader... the first optical character reader designed and priced for the small computer **$179**

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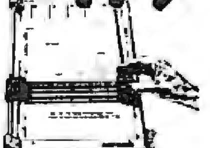
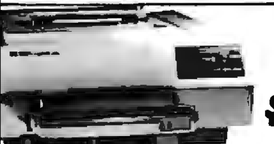


Uses a standard RS-232 serial port hookup to interface easily with your computer



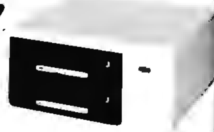
HEWLETT PACKARD LASER JET II $1895

New from Hewlett Packard the LaserJet Series II. More features than the LaserJet but at a much lower price.
Standard on the Series II is 512 K/byte memory expandable to 4 Megabytes, both serial and parallel ports. List price $2495 California Digital price $1895.
Memory upgrade, type fonts and toner cartridges available.

Other Laser Printers available:
Te as Instruments • Okidata • Apple • Ricoh Qume • AST Research • QMS • Xerox • Canon Quadram • Centronics • CIE C.Itoh • DataProducts

Bernoulli Box

was $3540 now only **$1595**



The **Bernoulli Box** by Iomega, features 10 and 20 megabyte removable cartridges, and delivers reliability, expandability, transportability, security and speed in one versatile subsystem. It lets you transfer megabytes of information safely and swiftly for primary or backup storage. Or combine several software programs onto a single cartridge for easy switching from one to another.
Reliable... the Box has incredible resistance to shock and vibration completely eliminating the possility of head crash.
Expandable... grow at your own pace by adding inexpensive cartridges. When **security** is essential, don't lock up your system... just lock up the cartridges.
The Bernoulli Box delivers preformance that often exceeds the best of hard disk speed and the convenience of floppy disks. At these prices don't be caught wishing you had one after a foss of irreplacable data.

		List	Our Price
10+10 Meg.	A2210H	$3450	1595
20+20 Meg.	A2220H	4540	2095
Bootable Controller		255	189
10 Meg. Cartridge		79	49
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21 Megabyte Gold Card $479

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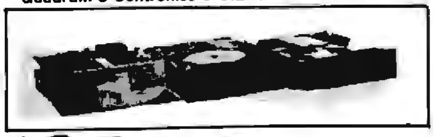

$35 We have them again... The Remex 480 was a sell out two years ago but we located an additional 10,000 units and are offering these 2/3 height IBM/PC compatible 360K/Byte drives at only $35 each at quantity two.

85 The Mitsubishi 4851 was probably the best 360 K/Byte drive ever produced. The production cost was too high and Mitsubishi discontinued the product. Quantity two $85 each.

115 The Panasonic 475 is jumper selectable between 96 TPI format and 1.2 Megabyte as used in the IBM/AT computer.
Suggested price of the 475 is $189 but California Digital located a computer manufacturer that had to liquidate stock making available 1000 of these choice drives. Quantity two $115 each.

	One	Two	Ten
REMEX 480 2/3 height for PC	39	35	call
MITSUBISHI 4851 360K/Byte	89	85	82
MITSUBISHI 4853 96 TPI.	99	95	92
MITSUBISHI new 501 half ht.	129	119	109
MITSUBISHI 504A AT comp.	169	159	155
TEAC FD55BV half height	109	99	89
TEAC FD55FV 96 TPI, half ht.	119	109	105
TEAC FD55GF for IBM AT	169	159	155
PANASONIC 455 Half Height	109	99	89
PANASONIC 475 1.2 Meg./96	119	115	109
Switching power supply			49
Dual enclosure for 5¼" drives			59

SONY $139

he Sony 53W is a 3½ inch double sided double density disk drive he drive can be connected to your existing floppy controller but nll require MS/DOS 3.2 to properly operate in the PC and compatbles. The 53W is similar to the drive being used in the PC portable.

Smarteam 2400 Baud $289

The Smarteam 2400 offers all the features of the Hayes Smart Modem 2400 for a fraction of the price. Now is your opportunity to purchase a 2400 baud modem for only $289.
Also available: The Smarteam 1200 at only $139

U.S. Robotics 2400 Internal $189

The US Robotics Micro 2400 modem is one hundred percent Hayes compatible, auto dial, auto answer, auto everthing. A super value at only $189

$99

This 300/1200 baud modem matches design specs of Bell 212A and for all practical purpose those of the Hayes Smart Modem. The Avatex brings you reliable data transmission for only $99.

OTHER MODEMS AVAILABLE:
Hayes • Universal Data • Fujitsu
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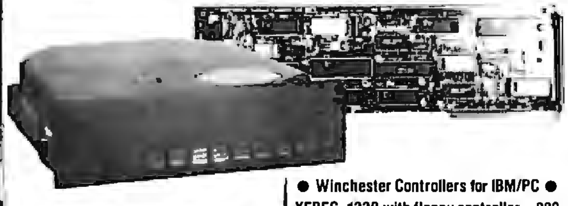
Seagate $459

30 MEGABYTE WINCHESTER HARD DISK KIT



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FUJITSU 2242 55 M. 35mS.	1399	1329
FUJITSU 2243 86 M. 35mS.	1895	1819
RODIME RD-202E 27 Meg.	659	629
RODIME RD-203E 40 Meg.	695	659
RODIME RD-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M	1829	1779
MAXTOR XT1140 140 Meg.	2595	2529
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OMTI 5527 RLL controller	159
ADAPTEC 2070 RLL controller	179
ADAPTEC 2010A	159
WESTERN DIGITAL WD/1002WX2	119

• SCSI/SASI Winchester Controllers •

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WESTERN DIGITAL 1002-05E 5¼"	289
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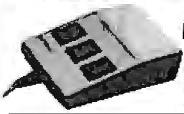

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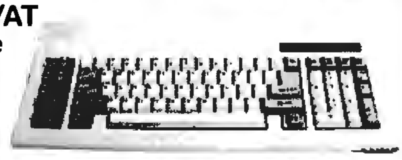
NEW! AT Style Layout



• Tactile touch keyswitches • AT style layout • Switch selectable between PC/XT or AT • Illuminated Caps Lock, Num Lock and Scroll Lock indicators • Low profile design • 8½ foot cord • Manual included • Size: 18"L x 7¼"W x 1½"H

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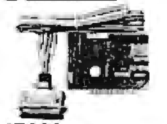

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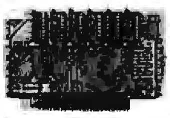

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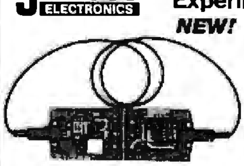

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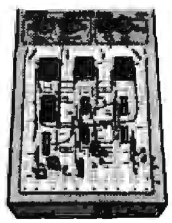

• Provides user with quick and efficient system for breadboarding electronic circuits • Components & wire leads can be quickly inserted and removed without soldering or desoldering • 3 regulated power supplies: 5V @ 1A, +5V to +15V @ .5A, –5V to –15V @ .5A • Power: 120VAC, 60Hz fused

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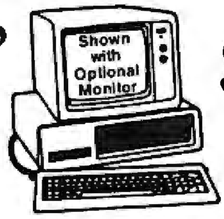

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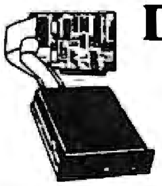

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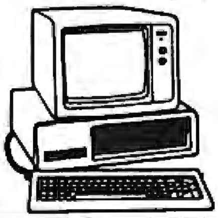

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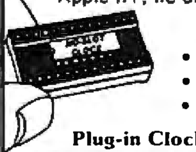

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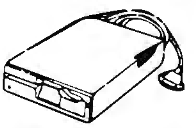

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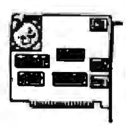

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4060	.69	74C193	1.49
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7408	.24	74154	1.49
7410	.19	74155	.75
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7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
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74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
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74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-93 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V 3A	TO-3	4.79
LM338K	Adj. 5A	TO-3	6.95
78H12K	12V 5A	TO-3	8.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTDOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

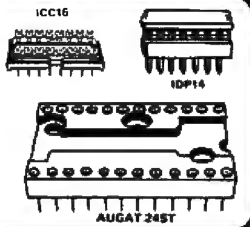
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	—	.95	.95	—	—	—	1.75	—	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

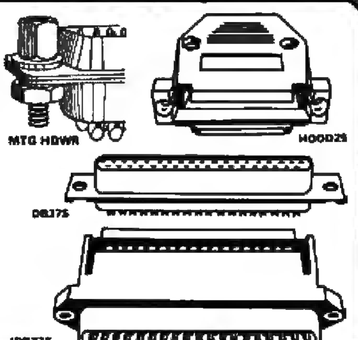
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP02	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	2.25
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	—	1.95	2.65	—
	FEMALE	DBxxSR	1.25	1.55	—	2.00	2.79	—
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	—	3.89	5.60	—
	FEMALE	DBxxSWW	2.76	4.27	—	6.84	9.95	—
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	—	3.98	5.70	—
	FEMALE	IDBxxS	2.92	3.20	—	4.33	6.76	—
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	—	—
	GREY	HOODxx	.65	.65	—	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	9.95

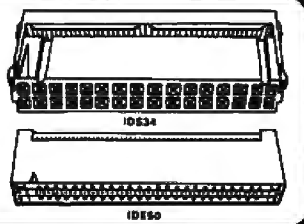
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

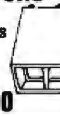
HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS



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Todd Wagner

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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Inquiry 146

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Certain early PCs may not run at 8 MHz-these machines may be switched to one of the slower speeds:
6.66 MHz=40% 7.37 MHz=55% 8.0 MHz=67%

SPECIAL ENDS 7/31/87

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PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

SPOOLS

100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

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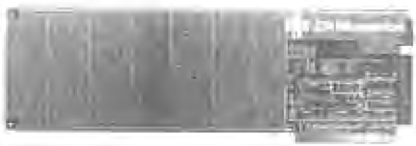
FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS



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BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
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P100-1	BARE - NO FOIL PADS	$15.15
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P100-4	SINGLE FOIL PADS PER HOLE	$22.75

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P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

EXTENDER CARDS

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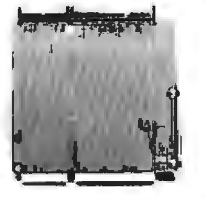

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- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC; SUCH AS IC #

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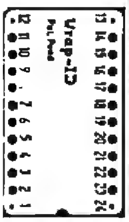
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
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PS-IBM $69.95
- FOR IBM PC-XTCOMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY

PS-IBM/150

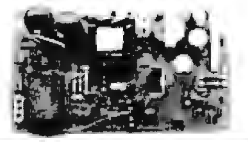
PS-IBM-150 $79.95
- FOR IBM PC-XTCOMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY

PS-130

PS-130 $99.95
- 130 WATTS
- SWITCH ON REAR
- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY

PS-A

PS-A $49.95
- USE TO POWER APPLE TYPE SYSTEMS, 79.5 WATTS
- +5V @ 7A, +12V @ 3A -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR



PS-1558

PS-1558 $34.95
- 75 WATTS, UL APPROVED
- +5V @ 7A, +12V @ 3A -12V @ 250ma, -5V @ 300ma

CAPACITORS

TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.65
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

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DIP	16 PIN	15 RESISTOR	1.09
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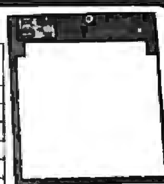
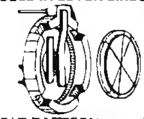
WBU-T	1.38 x 6.50"	---	---	1	630	---	6.95
WBU-204-3	3.94 x 8.45"	1	100	2	1260	2	17.95
WBU-204	5.13 x 8.45"	4	400	2	1260	3	24.95
WBU-206	6.88 x 9.06"	5	500	3	1890	4	29.95
WBU-208	8.25 x 9.45"	7	700	4	2520	4	39.95



WBU-208

LITHIUM BATTERY
AS USED IN CLOCK CIRCUITS



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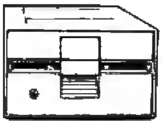

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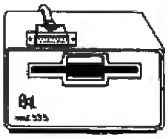
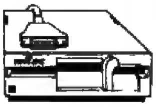
- SIX MONTH WARRANTY

DOUBLE SIDED!



MAC535
$249.95
- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE HAS AUTO-EJECT MECHANISM
- FULL ONE YEAR WARRANTY



AD-3C
$139.95
- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
- SIX MONTH WARRANTY

DISK DRIVE ACCESSORIES

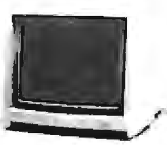
FDD CONTROLLER CARD	$49.95
IIc ADAPTOR CABLE	$19.95

ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

CRT MONITORS FOR ALL APPLICATIONS

CASPER
EGA MONITOR
- EGA & CGA COMPATIBLE
- SCANNING FREQUENCIES: 15.75 / 21.85 KHz
- RES: 640 x 200 / 350
- .31mm DOT PITCH, 25 MHz
- 16 COLORS OUT OF 64
- 14", BLACK MATRIX SCREEN

$399.95



CASPER
RGB MONITOR
- COLOR/GREEN/AMBER SWITCH ON REAR
- DIGITAL RGB-IBM COMPATIBLE
- 14" NON-GLARE SCREEN
- RESOLUTION: 640H x 240V
- .39mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

$299.95

SAMSUNG
MONOCHROME
- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE AMBER, LOW DISTORTION SCREEN
- RESOLUTION: 720H x 350V
- ATTRACTIVE CASE WITH SWIVEL BASE
- ONE YEAR WARRANTY

$119.95

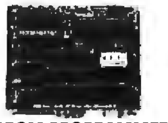
FORTRONICS
MONOCHROME
- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE SCREEN
- VERY HIGH RESOLUTION: 1100 LINES (CENTER)
- 25 MHz BANDWIDTH
- CABLE FOR IBM PC INCLUDED

AMBER OR GREEN AVAILABLE

$99.95

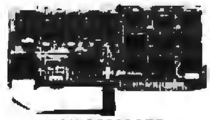
TILT & SWIVEL MONITOR STAND $12.95 WITH POWER CENTER $39.95

APPLE COMPATIBLE INTERFACE CARDS



EPROM PROGRAMMER
- DUPLICATE OR BURN ANY 27xx SERIES EPROM (2716 TO 27128)
- MENU-DRIVEN SOFTWARE
- HIGH SPEED WRITE ALGORITHM

RP-525 $59.95



16K RAMCARD
- FULL 2 YEAR WARRANTY
- EXPAND YOUR 48K MACHINE TO A FULL 64K OF MEMORY
- CAN BE USED IN PLACE OF THE APPLE LANGUAGE CARD

RAM-CARD $39.95

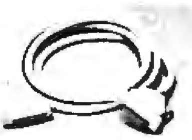
IC TEST CARD
- QUICKLY TESTS MANY COMMON ICs
- DISPLAYS PASS OR FAIL
- TEST 4000 & 74HC SERIES CMOS, 7400, 74LS, 74L, 74H & 74S

IC-TESTER $129.95

Seagate
5¼" HARD DISK DRIVES

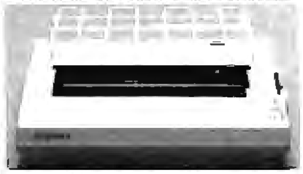
ST-225	HALF HT 20MB 65ms	$275
ST-238	HALF HT 30MB 65ms (RLL)	$299
ST-251	HALF HT 40MB 40ms	$599
ST-277	HALF HT 60MB 40ms (RLL)	CALL
ST-4038	FULL HT 30MB 40ms	$559
ST-4096	FULL HT 80MB 28ms	$1195

MOLDED INTERFACE CABLES
6 FOOT, 100% SHIELDED, MEETS FCC



IBM PARALLEL PRINTER CABLE	9.95
CENTRONICS (MALE TO FEMALE)	15.95
CENTRONICS (MALE TO MALE)	14.95
MODEM CABLE (FOR IBM)	7.95
RS232 SERIAL (MALE TO FEMALE)	9.95
RS232 SERIAL (MALE TO MALE)	9.95
KEYBOARD EXTENDER (COILED)	7.95
APPLE II JOYSTICK EXTENDER	4.95

C. ITOH RITEMAN II PRINTER



- 160 CPS DRAFT, 32 CPS NLQ
- 9 x 9 DOT MATRIX
- SUPPORTS EPSON/IBM GRAPHICS
- FRICTION AND PIN FEEDS
- VARIABLE LINE SPACING AND PITCH

$219.95

IBM PRINTER CABLE	$9.95
REPLACEMENT RIBBON CARTRIDGE	$7.95

½ HEIGHT FLOPPY DISK DRIVES

5¼" TEAC FD-55B DS/DD	$109.95
5¼" TEAC FD-55F DS/QUAD	$124.95
5¼" TEAC FD-55GFV DS/HD	$154.95
5¼" MITSUBISHI DS/HD	$129.95
3½" TOSHIBA KIT DS/DD	$149.95

KIT INCLUDES MOUNTING HARDWARE TO FIT 5¼" & FACEPLATES FOR AT & XT

DISK DRIVE ACCESSORIES

TEAC SPECIFICATION MANUAL	$5.00
TEAC MAINTENANCE MANUAL	$25.00
½ HT MNTG HARDWARE FOR IBM	$2.95
MOUNTING RAILS FOR IBM AT	$4.95
"Y" POWER CABLE FOR 5¼" FDDs	$2.95
5¼" FDD POWER CONNECTORS	$1.19

KB-1000 $79.95
CASE WITH KEYBOARD
FOR APPLE TYPE MOTHERBOARD
- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD W/ CURSOR CONTROL
- CAPS LOCK
- AUTO-REPEAT

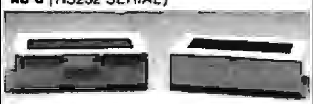
DISK DRIVE ENCLOSURES WITH POWER SUPPLIES

CAB-2SV5	DUAL SLIMLINE 5¼"	$49.95
CAB-1FH5	FULL HT 5¼"	$69.95
CAB-2SV8	DUAL SLIMLINE 8"	$209.95
CAB-2FH8	DUAL FULL HT 8"	$219.95

SWITCH BOXES
ALL LINES SWITCHED, GOLD PLATED CONNECTORS, QUALITY SWITCHES

2 WAY $39.95
- CONNECTS 2 PRINTERS TO 1 COMPUTER OR VICE VERSA

AB-P *(CENTRONICS PARALLEL)*
AB-S *(RS232 SERIAL)*



3 WAY $99.95
- CONNECTS 3 PRINTERS TO 1 COMPUTER OR VICE VERSA

SWITCH-3P *(CENTRONICS PARALLEL)*
SWITCH-3S *(RS232 SERIAL)*

NASHUA DISKETTES
NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED (COMPARING FLOPPY DISKS, BYTE 9/84)

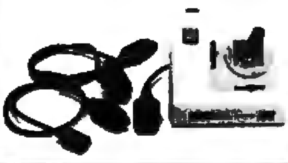
N-MD2D	DS/DD 5¼" SOFT	$9.90
N-MD2F	DS/QUAD 5¼" SOFT	$19.95
N-MD2H	DS/HD 5¼" FOR AT	$24.95
N-FD1	SS/DD 8" SOFT	$27.95
N-FD2D	DS/DD 8" SOFT	$34.95

BULK DISKETTE SALE
5¼" SOFT SECTOR, DS/DD W/TYVEC SLEEVES & HUB RINGS

$9.90	69¢ea	59¢ea
BOX OF 10	BULK QTY 50	BULK QTY 250

KEYBOARD-AP $49.95
- REPLACEMENT FOR APPLE II KEYBOARD
- CAPS LOCK KEY, AUTO-REPEAT
- ONE KEY ENTRY OF BASIC OR CP/M COMMANDS

JOYSTICK CB-10 $19.95
- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- ATTRACTIVE, SOLID, PLASTIC CASE
- INCLUDES ADAPTOR CABLE FOR IBM, APPLE II, IIe, II c, ATARI & VIC 20/64



BUILD STEVE CIARCIA'S INTELLIGENT EPROM PROGRAMMER
AS SEEN IN BYTE, OCT. 86
- STAND-ALONE OR RS-232 SERIAL OPERATION
- MENU SELECTABLE EPROM TYPES—NO CONFIGURATION JUMPERS
- PROGRAMS ALL 5V 27XXX EPROMS FROM 2716 TO 27512
- READ, COPY OR VERIFY EPROM
- UPLOAD/DOWNLOAD INTEL HEX FILES
- PROGRAMMER DRIVER USER MODIFIABLE

ONLY $199

KIT INCLUDES PCB AND ALL COMPONENTS EXCEPT CASE & POWER SUPPLY

DISKETTE FILES

5¼" DISKFILE	3½" DISKFILE
HOLDS 70	HOLDS 40
$9.95	$9.95

300B MODEM $49.95
FOR APPLE OR IBM
INCLUDES ASCII PRO-EZ SOFTWARE
- FCC APPROVED
- BELL SYSTEMS 103 COMPATIBLE
- INCLUDES AC ADAPTOR
- AUTO-DIAL
- DIRECT CONNECT

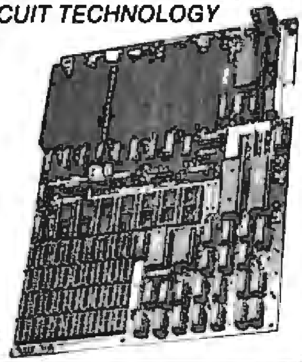
CABLE FOR APPLE IIc $14.95

POWER STRIP $12.95
- UL APPROVED
- 15A CIRCUIT BREAKER

CALL FOR VOLUME QUOTES Inquiry 147

EGA CARD AND MONITOR NOW ONLY $569!

QUALITY IBM COMPATIBLE MOTHERBOARDS
FROM MODULAR CIRCUIT TECHNOLOGY

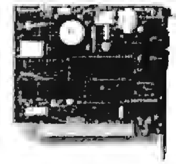


TURBO 4.77 / 8 MHz $129.95
JDR PART #: MCT-TURBO
- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED DURING DISKETTE OPERATION FOR MAXIMUM THROUGHPUT AND RELIABILITY
- CHOICE OF NORMAL / TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

STANDARD 4.77 MHz $109.95
JDR PART #: MCT-XTMB
- 8088 CPU, OPTIONAL 8087 CO-PROCESSOR
- 8 EXPANSION SLOTS
- EXPANDABLE TO 640K ON-BOARD MEMORY (0K RAM INSTALLED)
- ALL ICs SOCKETED-HIGHEST QUALITY PCB
- ACCEPTS 2764 OR 27128 ROMS

BOTH WITH FREE MCT BIOS!

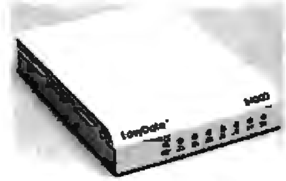
EASYDATA MODEMS
All models feature auto-dial/answer/redial on busy, Hayes compatible, power up self test, touchtone or pulse dialing, built-in speaker, PC Talk III Communications software, Bell Systems 103 & 212A full or half duplex and more.



INTERNAL
EASYDATA-12H $99.95
1200 BAUD HALF CARD

EASYDATA-12B $119.95
1200 BAUD 10" CARD

EASYDATA-24B $199.95
2400 BAUD FULL CARD



EXTERNAL
NO SOFTWARE INCLUDED

EASYDATA-12D $119.95
1200 BAUD

EASYDATA-24D $219.95
2400 BAUD

FARADAY FDD CONTROLLER
JDR PART #: FAR-FDD
- SUPPORTS UP TO 4 INTERNALLY MOUNTED FDDs
- IBM COMPATIBLE, INTERFACES TO 360K OR 720K USING DOS 3.20
- INCLUDES CABLE FOR 2 DISK DRIVES

$24.95

IBM COMPATIBLE FLOPPY DISK DRIVE
JDR PART #: FDD-360
GOOD QUALITY DRIVES BY MAJOR MANUFACTURERS SUCH AS QUME, TANDON & CDC
- 5¼" HALF HEIGHT
- 360K STORAGE CAPACITY
- DS/DD
- 48 TPI

$69.95

IBM STYLE COMPUTER CASE
AN ATTRACTIVE STEEL CASE WITH A HINGED LID. FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS

- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

$34.95

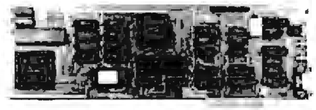
SLIDE TYPE CASE $39.95

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

XT MOTHERBOARD	$109.95
PRO-BIOS (A $20 VALUE)	FREE!
256K RAM	$26.55
130 WATT POWER SUPPLY	$69.95
FLIP-TOP CASE	$34.95
KEY TRONIC™ KEYBOARD	$49.95
360K DRIVE	$69.95
FARADAY CONTROLLER	$24.95
MONOCHROME ADAPTOR	$49.95
FORTRONICS MONITOR	$99.95
TOTAL:	$536.15

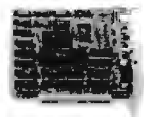
DISPLAY CARDS
FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EGA $179.95
100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS



- COMPATIBLE WITH IBM EGA, COLOR GRAPHICS AND MONOCHROME ADAPTORS
- TRIPLE SCANNING FREQUENCY FOR DISPLAY ON EGA, STANDARD RGB OR HIGH RESOLUTION MONOCHROME MONITOR
- FULL 256K OF VIDEO RAM ALLOWS 640 x 350 PIXELS IN 16 OF 64 COLORS
- LIGHT PEN INTERFACE

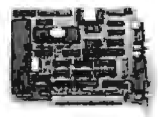
MCT-CG $49.95
COMPATIBLE WITH IBM COLOR GRAPHICS STANDARD



- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- SUPPORTS RGB, COMPOSITE MONOCHROME & COLOR AND AN RF MODULATOR OUTPUT
- 320 x 200 COLOR GRAPHICS MODE
- 640 x 200 MONOGRAPHICS MODE
- LIGHT PEN INTERFACE

SHORT SLOT

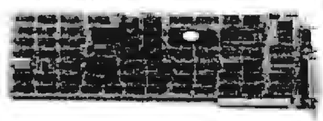
MCT-MGP $59.95
COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS



- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- PARALLEL PRINTER PORT, CONFIGURABLE AS LPT1 OR LPT2
- 720 x 348 GRAPHICS MODE
- LOTUS COMPATIBLE
- CAN RUN WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

SHORT SLOT

MCT-MG $79.95
COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS



- SERIAL PORT OPTION
- PARALLEL PRINTER PORT
- 720 x 348 GRAPHICS MODE
- 80 x 25 TEXT MODE
- LOTUS COMPATIBLE
- SELECTABLE TO RUN ALONG WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM

MG-SERIAL OPTIONAL SERIAL PORT $19.95

MCT-MONO $49.95
ANOTHER FANTASTIC VALUE FROM JDR!
- IBM COMPATIBLE TTL INPUT
- 720 x 348 PIXEL DISPLAY

PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS AND DOES NOT INCLUDE A PARALLEL PORT

IBM COMPATIBLE KEYBOARDS

MCT-5150 $59.95
- "5150" STYLE KEYBOARD
- FULLY IBM COMPATIBLE
- LED STATUS INDICATORS FOR CAPS & NUMBER LOCK
- LARGE, EASY TO REACH SHIFT & RETURN KEYS
- 83 KEY TYPEWRITER LAYOUT

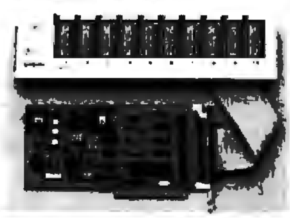
MCT-5151 $79.95
- REPLACEMENT FOR KEY TRONIC™ KB-5151 KEYBOARD
- SEPARATE CURSOR & NUMERIC KEYPAD
- CAPS LOCK & NUMBER LOCK INDICATORS
- IMPROVED KEYBOARD LAYOUT

MCT-5060 $59.95
- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE

MCT-5339 $89.95
- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- 12 FUNCTION KEYS
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

EPROM PROGRAMMERS
FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EPROM $129.95
PROGRAMS 27xx AND 27xxx SERIES EPROMS UP TO 27512



- SUPPROTS VARIOUS MANUFACTURERS FORMATS WITH 12.5, 21 AND 25 VOLT PROGRAMMIMG
- MENU-DRIVEN SOFTWARE ALLOWS EASY MANIPULATION OF DATA FILES
- SPLIT OR COMBINE THE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY WITH EASY ONE KEY SELECTION
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS

4 GANG PROGRAMMER $169.95
10 GANG PROGRAMMER $299.95

MCT PRODUCTS CARRY A ONE YEAR WARRANTY

1200B MODEM $99.95 FOR IBM W/ SOFTWARE 2400B MODEM $199.95

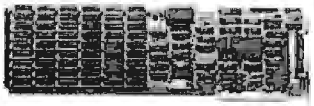
MULTIFUNCTION CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-MF $79.95

ALL THE FEATURES OF FAST'S SIX PACK PLUS AT HALF THE PRICE!

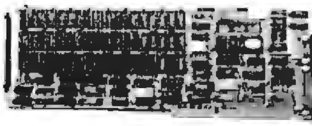
- 0-348K DYNAMIC RAM USING 4164s
- INCLUDES SERIAL PORT, PARALLEL PRINTER PORT, GAME CONTROLLER PORT AND CLOCK/CALENDAR
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR



MCT-ATMF $139.95

ADDS UP TO 3 MB OF 1 BIT RAM TO THE AT

- USER EXPANDABLE TO 1.5 MB OF ON-BOARD MEMORY (NO MEMORY INSTALLED)
- FLEXIBLE ADDRESS CONFIGURATION
- INCLUDES SERIAL PORT, PARALLEL PORT
- OPTIONAL PIGGYBACK BOARD PERMITS EXPANSION TO 3 MB



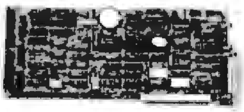
ATMF-SERIAL 2nd SERIAL PORT $24.95

MCT-ATMF-MC $29.95
PIGGYBACK BOARD (ZERO K INSTALLED)

MCT-MIO $79.95

A PERFECT COMPANION FOR OUR MOTHERBOARD

- 2 DRIVE FLOPPY DISK CONTROLLER
- INCLUDES SERIAL PORT, PARALLEL PORT, GAME PORT AND CLOCK/CALENDAR WITH BATTERY BACK-UP
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR



MIO-SERIAL 2nd SERIAL PORT $15.95

MCT-IO $59.95

USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OT LPT2 (x378 OR x278)
- CLOCK/CALENDAR WITH A BATTERY BACK-UP

SHORT SLOT

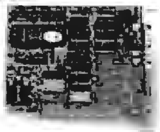
IO-SERIAL 2nd SERIAL PORT $15.95

MCT-ATIO $59.95

USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPTA OR LPTB (x378 OR x278)
- GAME PORT
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION IN AN AT

SHORT SLOT



ATIO-SERIAL 2nd SERIAL PORT $24.95

RAM CARDS

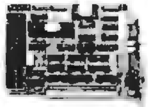
FROM MODULAR CIRCUIT TECHNOLOGY

MCT-RAM $69.95

A CONTIGUOUS MEMORY SOLUTION FOR YOUR SHORT OR REGULAR SLOT

- SHORT SLOT, LOW POWER PC COMPATIBLE DESIGN
- CAN OFFER UP TO 576K OF ADDITIONAL MEMORY
- USER SELECTABLE CONFIGURATION AMOUNTS OF 192, 384, 512, 256 & 576K, USING COMBINATIONS OF 64 & 256K RAM

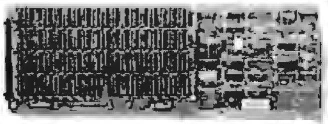
SHORT SLOT



MCT-ATRAM $149.95

A POWER USER'S DREAM, 4MB OF MEMORY FOR THE AT

- USER EXPANDABLE TO 2MB OF ON-BOARD MEMORY
- USES FULL 16 BIT PARITY CHECKED MEMORY, 64K OR 256K DYNAMIC RAM
- FLEXIBLE STARTING ADDRESS, ROUND OUT CONVENTIONAL MEMORY TO 640K & ADD EXTENDED MEMORY ABOVE 1MB

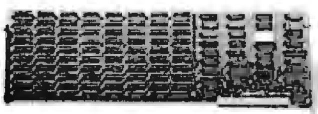


MCT-ATRAM-MC $39.95
2MB PIGGYBACK BOARD (ZERO K INSTALLED)

MCT-EMS $129.95

2MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR THE XT

- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- USES 64K OR 256K DYNAMIC RAM (NO MEMORY INSTALLED)
- USE AS EXPANDED OR CONVENTIONAL MEMORY, RAMDISK OR SPOOLER
- SOFTWARE INCLUDES EMS DEVICE DRIVERS, PRINT SPOOLER AND RAMDISK



MCT-ATEMS AT VERSION OF THE MCT-EMS $139.95

Seagate

HARD DISK SYSTEMS

20 MB $339 30 MB $399

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Seagate 40 MB AT DRIVE

FAST 40ms ACCESS TIME

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QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT

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- USES STANDARD DB37 CONNECTOR FOR EXTERNAL DRIVES
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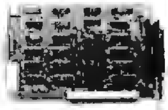

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HARD DISK CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL

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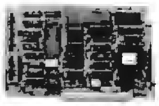
- INCLUDES CABLING FOR 1 INTERNAL DRIVE

SHORT SLOT



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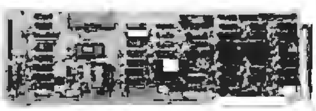
- ALL POPULAR HDD SIZES ARE SUPPORTED, INCLUDING 5, 10, 20, 30 & 40MB
- CAN DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES



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BOMB RESULTS

First place in March goes to BYTE's Product Preview of "The Commodore A2000" by editors Gregg Williams, Tom Thompson, and Richard Grehan. In second place and the winner of $100 is John F. Asmus for "Digital Image Processing in Art Conservation." Ken Sheldon's "Probing Space by Camera" placed third, followed by George Stewart's Product Preview of "Turbo BASIC." Next in line is What's New and Ciarcia's Circuit Cellar, in which Steve Ciarcia shows how to "Build a Trainable Infrared Master Controller." Winner of the $50 award for being the second nonstaff author to appear in the lineup is Benjamin M. Dawson for his "Introduction to Image Processing Algorithms." The $50 award for quality again goes to John F. Asmus for his close look at the evolution of the *Mona Lisa*. Congratulations to all.

COMING UP IN BYTE

Theme:
Local area networks will be July's theme, with emphasis planned for topics like testing networks to see what load they can take; how to link Macintoshes into a Unix network; how to archive your data; a look at an Amiga network file server, a discussion of a LAN-based spreadsheet, and an examination of some LAN database software.

Features:
Planned features include the Intel 82786 graphics chip, Karmarkars algorithm, and map storage on CD-ROMs.

Circuit Cellar:
After building an image processor, Steve Ciarcia will discuss image-processing software.

Programming Project:
An article on recursive fractals (in BASIC).

Programming Insight:
Complex math in Pascal.

Special 68000 Series:
Remotely controlling scientific apparatus with a Macintosh and a specially developed object-oriented language.

Reviews:
Different ADA implementations for the IBM PC, an advanced debugging tool, a music program, and a roundup of CAD packages for use on the Macintosh.

EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue.
Each reference is to the first page of the article or section in which the company name appears.

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4. □ □ □ [#] [#] 9. □ □ □ [#] [#] 13. □ □ □ [#] [#] 17. □ □ □ [#] [#]
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5	27	49	71	93	115	137	159	181	203	225	247	269	291	313	335	357	379	401	423	445	467	489	511	533	555	577	599	621	643	665	687	709	731	753	775	797
6	28	50	72	94	116	138	160	182	204	226	248	270	292	314	336	358	380	402	424	446	468	490	512	534	556	578	600	622	644	666	688	710	732	754	776	798
7	29	51	73	95	117	139	161	183	205	227	249	271	293	315	337	359	381	403	425	447	469	491	513	535	557	579	601	623	645	667	689	711	733	755	777	799
8	30	52	74	96	118	140	162	184	206	228	250	272	294	316	338	360	382	404	426	448	470	492	514	536	558	580	602	624	646	668	690	712	734	756	778	800
9	31	53	75	97	119	141	163	185	207	229	251	273	295	317	339	361	383	405	427	449	471	493	515	537	559	581	603	625	647	669	691	713	735	757	779	801
10	32	54	76	98	120	142	164	186	208	230	252	274	296	318	340	362	384	406	428	450	472	494	516	538	560	582	604	626	648	670	692	714	736	758	780	802
11	33	55	77	99	121	143	165	187	209	231	253	275	297	319	341	363	385	407	429	451	473	495	517	539	561	583	605	627	649	671	693	715	737	759	781	803
12	34	56	78	100	122	144	166	188	210	232	254	276	298	330	342	364	386	408	430	452	474	496	518	540	562	584	606	628	650	672	694	716	738	760	782	804
13	35	57	79	101	123	145	167	189	211	233	255	277	299	321	343	365	387	409	431	453	475	497	519	541	563	585	607	629	651	673	695	717	739	761	783	805
14	36	58	80	102	124	146	168	190	212	234	256	278	300	322	344	366	388	410	432	454	476	498	520	542	564	586	608	630	652	674	696	718	740	762	784	806
15	37	59	81	103	125	147	169	191	213	235	257	279	301	323	345	367	389	411	433	455	477	499	521	543	565	587	609	631	653	675	697	719	741	763	785	807
16	38	60	82	104	126	148	170	192	214	236	258	280	302	324	346	368	390	412	434	456	478	500	522	544	566	588	610	632	654	676	698	720	742	764	786	808
17	39	61	83	105	127	149	171	193	215	237	259	281	303	325	347	369	391	413	435	457	479	501	523	545	567	589	611	633	655	677	699	721	743	765	787	809
18	40	62	84	106	128	150	172	194	216	238	260	282	304	326	348	370	392	414	436	458	480	502	524	546	568	590	612	634	656	678	700	722	744	766	788	810
19	41	63	85	107	129	151	173	195	217	239	261	283	305	327	349	371	393	415	437	459	481	503	525	547	569	591	613	635	657	679	701	723	745	767	789	811
20	42	64	86	108	130	152	174	196	218	240	262	284	306	328	350	372	394	416	438	460	482	504	526	548	570	592	614	636	658	680	702	724	746	768	790	812
21	43	65	87	109	131	153	175	197	219	241	263	285	307	329	351	373	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	747	769	791	813
22	44	66	88	110	132	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528	550	572	594	616	638	660	682	704	726	748	770	792	814

BYTE's ongoing monitor box (BOMB) lets you rate each article you've read in BYTE as excellent, good, fair, or poor. Each month, you can mail in the BOMB card found at the back of each issue. We tally your votes, total the points, tell you who won, and award the two top-rated nonstaff authors $100 and $50, respectively. An additional $50 award for quality goes to the nonstaff author with the best average score (total points divided by the number of voters). If you prefer, you can use BIX as your method of voting. We welcome your participation.

Article No.*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Excellent	1	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97
Good	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98
Fair	3	7	11	15	19	23	27	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	95	99
Poor	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100

Article No.*	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Excellent	101	105	109	113	117	121	125	129	133	137	141	145	149	153	157	161	165	169	173	177	181	185	189	193	197
Good	102	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	194	198
Fair	103	107	111	115	119	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199
Poor	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200

* To determine this month's Article No., see BOMB as listed in Table of Contents under Departments

Name ______
Title ______
Company ______
Address ______
City ______
State ______ Zip ______
Telephone ______

A. What is your principal occupation? (Please check one only.)
1. ☐ Business Owner
2. ☐ Manager/Administrator
3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify) ______

B. How many people does your company employ?
1. ☐ 1–49
2. ☐ 50–999
3. ☐ 1,000 or more

C. Information requested for:
1. ☐ Business use
2. ☐ Personal use
3. ☐ Both

D. Do you plan to purchase items inquired about within:
1. ☐ Next 3 months?
2. ☐ Next 6 months?
3. ☐ Next 12 months?

E. Please check the statement that best describes your involvement in your company's purchasing decisions. (Check all that apply.)
1. ☐ I determine the need
2. ☐ I evaluate products/systems
3. ☐ I select/recommend the vendor
4. ☐ I approve/authorize the purchase

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INTRODUCING THE PINWRITER P9XL. YOU WON'T BELIEVE WHAT IT DOES TO THE AVERAGE BUSINESS LETTER.

Fasten your seatbelts. The new Pinwriter® P9XL printer from NEC is about to take off.

It cruises at 400 characters per second in draft mode, 140 characters per second in letter quality mode. Which means it can really make those business letters fly. In fact, no other 24-pin printer is faster.

```
It's our fastest
printer yet.
```

Actual print sample from the PinwriterP9XL printer.

NEC PRINTERS. THEY ONLY STOP WHEN YOU WANT THEM TO.

And because it uses a 24-pin printhead and a multistrike film ribbon—the same kind that's used in typewriters and letter-quality printers—the P9XL also delivers better print quality than its competitors. It even prints in color.

But it's not limited to letters. The Pinwriter P9XL is a true multi-purpose printer that can fly through payroll, invoices, continuous forms, multi-part forms—just about any business or office application.

Best of all, it's from NEC—the world's largest manufacturer of 24-pin printers. The company that consistently offers you the highest reliability ratings in the industry. (You can expect your P9XL to run for five years before it might need a repair.)

So don't waste any more time. Fly down to your nearest dealer and ask to see the new Pinwriter P9XL. Or call NEC at 1-800-343-4418 (in A, (617) 264-8635). Or if you prefer, write to NEC Information Systems, Dept. 1610, 1414 Massachusetts Ave., Boxborough, A 01719.

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NEC

NEC Information Systems, Inc.

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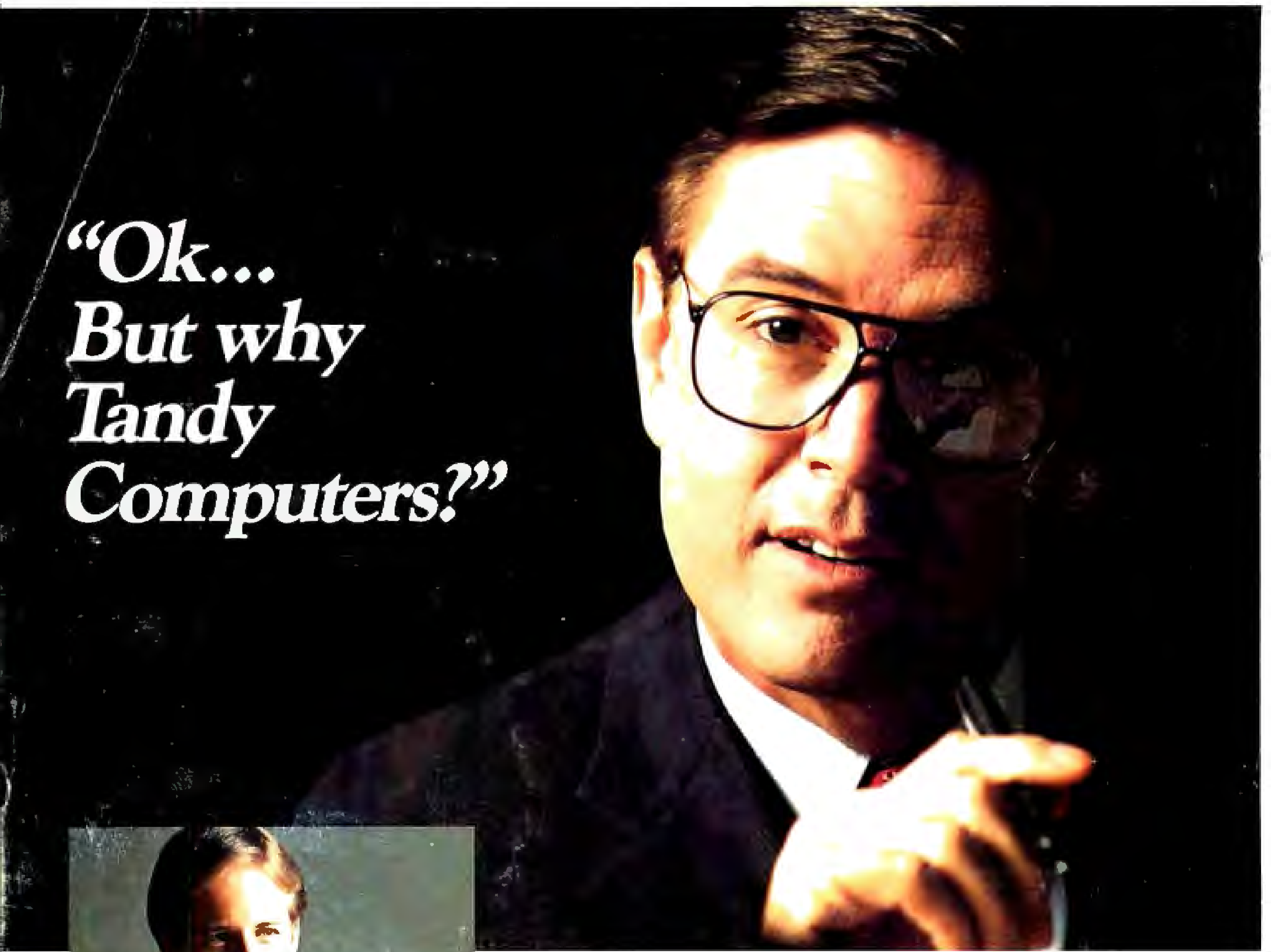

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