Computer-Aided Design

The IBM Personal System/2
Microsoft's New DOS
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2. Select the “Solve” command
3. Look at the answer
4. You’re done
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• Plot a graph
• Generate a report, then send the output to your printer, disk file or screen
• Or all of the above

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• Context-sensitive Help
• On-screen calculator
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• Built-in and user-defined math and financial functions
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• Polynomial finder
• Inequality solutions

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New Turbo Prolog Toolbox features include:

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- Complete communications package
- File transfers from Reflex, dBASE III, Lotus 1-2-3, Symphony
- A unique parser generator
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2. Exponential
3. Logarithm
4. 5-term Fourier
5. 5-term Polynomial

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Turbo Pascal 3.0 includes 8087 & BCD features for 16-bit MS-DOS and CP/M-80 systems. CP/M-80 version minimum memory: 48K. 8087 and BCD features not available. 128K.
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Steve Gibson, InfoWorld

Borland's Turbo Basic has advantages over the Microsoft product, including support of the high-speed 8087 math chip.

John C. Dvorak

A technical look at Turbo Basic

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- Floating-point support, with full 8087 (math co-processor) integration. Software emulation if no 8087 present
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- Full 80-bit precision
- Full window management

System requirements

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System requirements

IBM PC, XT, AT and true compatibles. PC-DOS (MS-DOS) 2.0 or later. One floppy drive. 320K

Sieve benchmark (25 iterations)

<table>
<thead>
<tr>
<th>Turbo C</th>
<th>Microsoft* C</th>
<th>Lattice C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compile time</td>
<td>3.89</td>
<td>16.37</td>
</tr>
<tr>
<td>Compile and link time</td>
<td>9.94</td>
<td>29.06</td>
</tr>
<tr>
<td>Execution time</td>
<td>5.77</td>
<td>9.51</td>
</tr>
<tr>
<td>Code size</td>
<td>274</td>
<td>297</td>
</tr>
<tr>
<td>Price</td>
<td>$99.95</td>
<td>$450.00</td>
</tr>
</tbody>
</table>

Benchmark run on a 6 Mhz IBM AT using Turbo C version 1.0 and the Turbo Linker version 1.0; Microsoft C version 4.0; the MS overlay linker version 3.51; Lattice C version 3.1 and the MS object linker version 3.05.

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- Optional Microsoft Mouse

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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 also provides multitasking. 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 late 1987. 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 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 late 1987. 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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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 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.

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

Rod Swanson Napa, CA

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.
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Thank you 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 Macintosh.

Let's start with the graphics display. If 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 a problem, too. It can be software-selected, as shown by the paint program, NEOchrome, 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/M80 emulator put out by Atari; the Macintosh emulator, MagicSac; 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

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tash, 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 "Suite of the Art in Dot-Matrix Impact Printers" by Jane Morrill Tazelaa 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 iteration 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
"It outperforms the competition at a price that is simply the best deal on the market."

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automaton with a given rule and a given initial state will lead to a cyclic structure of long period, a finite structure of long life, or some other possibility. Therefore, the approach taken by this program is not naive. We are not playing a trivial game whose outcome could be more easily predicted by a more sophisticated mathematical approach.

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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Version 2.0 is also unbelievably easy to install. To set up your files, you simply answer five easy questions. Dae-Easy has a new expanded manual plus context sensitive help to guide you every step of the way.

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JUNE 1987 • BYTE 23
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System 1800 Features:
- 5/8/10MHz: Selectable with 10MHz 80386 CPU Chip
- Fully compatible IBM AT™ AMI BIOS with built-in SET-UP UTILITY
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- 48 hour burn-in
- 512K RAM standard expandable to 1MB
- 200 pages of documentation
- Clock/Calendar with battery backup
- Hard disk/Floppy Controller
- UL/CSA approved 185 Watt power supply
- Made in U.S.A.
- 1 Year Warranty

System 1800 Models

<table>
<thead>
<tr>
<th>WAIT STATE</th>
<th>MODEL NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>System 1800-0 (5MHz)</td>
</tr>
<tr>
<td>1</td>
<td>System 1800-A (10MHz)</td>
</tr>
<tr>
<td>0</td>
<td>System 1800-B (10MHz)</td>
</tr>
</tbody>
</table>

Over 30,000 units installed
IBM is a registered trademark for International Business Machine Corporation.

Inquiry 104 for End-Users. Inquiry 105 for DEALERS ONLY.
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 Schecter
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)
Imagine the speed and power of a $100,000 minicomputer in a desktop PC costing under $7,000. Now imagine all that power going to waste because the operating system you chose was never meant to take advantage of a computer this powerful. It will take more than just a "window environment" or an outdated operating system to unlock the 80386.

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More Than Just Windows, We've Opened Doors.
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:

\[
\text{Area}(OAB) = \text{Area}(OEFD) - \text{Area}(OEB)
\]

\[
\begin{align*}
\text{Area}(OEFD) &= \frac{1}{2} \times (x_1y_2 - x_2y_1) - \frac{1}{2} \times (x_1y_2 - x_2y_1 - x_3y_1 - x_2y_2) \\
\text{Area}(OEB) &= \frac{1}{2} \times (x_1y_2 - x_2y_1 - x_3y_1 - x_2y_2)
\end{align*}
\]

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
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—Jonatho~ Sachs, Micro/Systems Journal, April, 1986

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Inquiry 176
spend more than $300. We also have to contend with questions about hardware and software bought through mail order. I use computers; I know what Unix and Xenix are. I have been told that I am honest and know what I am doing in regard to computers. But those very same people who tell me how important it is for them to buy from a knowledgeable source will buy from another vendor because his prices are $25 cheaper.

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 Multi-
INTRODUCING FAST FORWARD.
NOW ANY SOFTWARE CAN RUN UP TO 10 TIMES FASTER.

No more doodling while your database goes digging. Or lollygagging while your spreadsheet loads. Or taking five while your word processing program takes forever.

With Fast Forward, any software runs 2 to 10 times faster.

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Fast Forward can. Normally, your computer is constantly going to your disk and wading through massive amounts of data.

But with Fast Forward, data is retained in your computer's internal memory. Which is incredibly fast. Much faster than hard disks. Hundreds of times faster than floppies.

FAST FORWARD PERFORMANCE

<table>
<thead>
<tr>
<th>Software</th>
<th>With Fast Forward</th>
<th>Without Fast Forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>dBase III</td>
<td>3.15 minutes</td>
<td>29.6 minutes</td>
</tr>
<tr>
<td>(Test: Add and delete 225 records)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WordStar 3.3</td>
<td>40 seconds</td>
<td>1:11 seconds</td>
</tr>
<tr>
<td>(Test: Move cursor to end of 45 page document)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lotus 1-2-3</td>
<td>21 seconds</td>
<td>51 seconds</td>
</tr>
<tr>
<td>(Test: Load spreadsheet. 8 columns by 962 rows)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All tests done on 640K IBM PC, 20 megabyte hard disk and floppy drive. 320K RAM allocated to Fast Forward.

THE MORE YOU USE IT, THE FASTER YOU GO.

Once installed, Fast Forward works invisibly. As you use data, it's automatically stored in your computer's memory—and instantly available the next time you need it. Programs requiring frequent disk access (like dBase III) will show amazing improvements. And adding extended memory gives Fast Forward more room to work. So software runs even faster.

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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 "d:"") 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 a result, I may be harsher to the Amiga. I can't say for sure—I don't have an Amiga. But keep in mind that programmers have no control over the hardware. They must create and test their programs using the hardware they have. 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 great 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 and Z80 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 5½-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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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, Footer, 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 Sprintfor for travel.

Glad to hear about the Epson Geneva. I've never actually seen one, strange to say.—Jerry
Now you can run DOS on your AT or compatible while others use UNIX from their terminals. With DOSMERGE, the program that lets you chart profits with Lotus 1-2-3 while they enter sales and check inventory under UNIX. Even use the best programming utilities from DOS and UNIX on the same files without reformattting or partitioning your hard disk. So you can compile a UNIX program and run a UNIX utility while editing text under DOS.

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If you need to connect more peripherals, ECCCELL offers optional serial/parallel or dual serial ports. Unlike other cards, if you don't need them, you don't pay for them.

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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.

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."
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 checking (and into which the third-party designers: lab instruments because the status of these products from clashing. The panel consisting of Bob Carr, Andy Hertzfeld, Scott Kim, Charles Simonyi, Jaron Lanier, John Page, and 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-
Real programmers don't use dBASE. Or do they? We're finding that some very swift programmers are using it to write some very fast applications, and are completing their projects much more quickly. But they cheat. They use our Clipper compiler to combine dBASE with C and assembler. With dBASE used like pseudo-code, they can then quickly create prototypes that actually run.

Then, with dBASE doing the high-level database functions, they use our Clipper compiler to link in C or assembly language modules from their own bag of tricks. And they're finding that they're linking in less than they expected because Clipper compiled code runs so fast and because of Clipper's built-in enhancements.

Clipper includes easy networking that provides file and record locking the way it should be done. Fast screens that can be treated as memory variables and eliminate the need for direct screen writes and all that tortuous heap management code. Box commands that make windowing a breeze. And more.

So if you'd like to use your time more productively, check us out:
Nantucket Corporation,
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Clipper could get you out of the soup.

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Inquiry 203 for End-Users. Inquiry 204 for DEALERS ONLY.
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 show 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."

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 "next evolutionary step" in display technology, said panelists at the West Coast Computer Fair 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 return-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
- DeskSet
- Pagemaster
- Rim Systems
- Compound Document Processor
- Display Ad Make-up System

**COMPUTER-AIDED DESIGN**
- AutoCAD
- Cadvance
- Draftr 1
- In-A-Vision
- Generic CADD
- VersaCAD ADVANCED
- Workview
- Procad PC
- P-CAD System

**GRAPHICS SYSTEM TOOLS**
- MS-Windows
- GEM
- MetaWindows
- HALO
- KEE PC

IBM is a registered trademark of International Business Machines Corp.
It's simple.
With Intel's Inboard™ 386/AT.
It fits right into your IBM® AT or compatible, and gives you all the performance of a 386 system.

Without having to buy a 386 system. (Which, if you've priced one lately, is about three times as expensive.)

Inboard 386 is based on the revolutionary 32-bit, 16 MHz 80386 chip we invented. So it'll work with all the software you've got sitting on your desk. As well as any add-in boards you may have hiding in your computer—like, just for instance, the Above™ Board. Which we also invented.

Inboard 386 lets you whiz through recalc with Lotus® 1-2-3. And it makes your network server serve you even faster. In fact, it'll make any program serve you faster.

And with 386 control software,
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.)

Don't forget our five-year warranty. Or toll-free technical support line.

To find out more, check with your favorite computer dealer or call us at (800) 538-3373. And see why Inboard 386 beats the system.
Now you can maximize your MultiSync monitor—with a SuperEGA card from Genoa. SuperEGA gives you CGA (including double-scan), MDA (Hercules), EGA, and PGA resolution—and 132 columns. Or you can get the SuperEGA HiRes card for your advanced CAD/CAM and desktop publishing applications.

Both SuperEGA cards feature AutoSync; they automatically synchronize with all MultiSync speeds, from 15.75 up to 35 KHz.

The SuperEGA HiRes is the only EGA board with 800 x 600 resolution, and it comes with the drivers you need for CAD/CAM and desktop publishing.

For all your graphic applications, you can count on SuperEGA. We've maximized the MultiSync!

Call or write: Genoa Systems Corporation, 73 E. Trimble Road, San Jose, CA 95131; Telephone: 408-432-9090, FAX: 408-434-0997, TELEX: 172319
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 4½ 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 push-buttons: 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 co-processors, and 256K bytes of 70-nanosecond RAM.

Using a 25-MHz system clock, the system executes 1.29 million 80-bit floating-point
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.

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.

Ryan-McFarland's Development Tools

M/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
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 mathematical 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 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

Why spend another minute doing calculations by hand or writing and debugging programs? Put MathCAD to work for you and find out why PC Magazine writes, "Warning: it could prove addictive." Once you've tried MathCAD, it's hard to imagine how you ever got along without it.

To order MathCAD at just $249, call us today at: 1-800-MathCAD (In Massachusetts: 617-577-1017)

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

JUNE 1987 • BYTE 47
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.

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 1¾ by 4 ¼ 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.
A TRIBUTE TO THE 24-PIN PRINTER.

You're looking at all the printer you'll ever need. For any application you'll ever have.

The Citizen™ Tribute™ 224. A 24-pin dot matrix solution offering superb word processing, spreadsheet, graphics and data processing applications. At a price you'll find surprisingly affordable.

The Tribute 224 delivers true letter-quality printing at 66 cps, correspondence-quality at 132 cps, and drafts at 200 cps (at 10 cpi). In standard or proportional spacing. And optional IC cards enable fonts and emulations to be easily expanded.

You also get high-resolution graphics. A built-in, push-feed, variable-width tractor and automatic paper loading system. Both serial and parallel interfaces for flexible hardware compatibility. Front panel access to most print functions. And compatibility with virtually every major software package.

All this, and it's backed by our nationwide service, excellent documentation, and 12-month warranty.

For more information, call 1-800-556-1234, Extension 34. In California, call 1-800-441-2345, Extension 34.

The Citizen Tribute 224.

There is no higher tribute to 24-pin printing.

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3Com's Workstation Goes Diskless

Station 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.

Polaroid's Higher-Resolution Image Recorder

The PalettePlus Recorder is Polaroid's high-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 hard-copy 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 4½-inch film back, an autocord 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, 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.
Problem: Mysterious Data Loss
Solution: New Verbatim DataHold Protects when Static Strikes.

Static Danger is Everywhere. Your data is vulnerable to loss from an unseen enemy—static electricity! Even small static charges could cause sudden mysterious data loss from your diskette.

And static lurks everywhere. Just walk across a carpeted floor and you build up a static charge of up to 1,500 volts—enough to ZAP your data.

It's DataHold or Data Loss. DataHold is Verbatim's ingenious diskette liner that disperses damaging static charges instantly. Compare DataLife to other popular brands which retain static charges up to four minutes and your choice should be obvious.

DataHold, available exclusively from Verbatim DataLife, for unsurpassed data protection. After all, it's your choice, DataHold or data loss.
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 12½-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.

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), a 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 9½ 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.
Inquiry 593.

Kaypro’s Complete Publishing System

xtra! xtra! 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 5¼ 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 Single-user, single-tasking operating system that reads and writes MS-DOS-formatted disks.

Price: $395.
Inquiry 595.

continued
Introducing

CADKEY 3
REAL WORLD DESIGN

Tools, Not Toys.
CADKEY quickly became the world’s leading PC-based mechanical engineering system, with more than 25,000 installations, by pioneering the concept of a fully-integrated 2D-Drafting and 3D-Design system. We gave engineers real design tools, not toys. After all, the real world is three dimensional, not flat.

Real-World Solutions.
Now CADKEY 3 brings more real-world solutions to the PC by integrating all of the useful functions of surface-modeling, programmability, macro and tablet customization, and much more...

CADKEY 3 is a design toolbox stuffed with features:
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- Customizable-Tablet Templates
- ANSI and ISO Drafting with Ordinate-Dimensioning
- A 3-D IGES Translator
- FEA and Multi-Axis NC Integration
- Family-of-Parts Creation
- Bill-of-Materials Generation
- Technical Publishing Links
- Compatibility with All Popular Hardware
- A Complete Training and Support Network
- World-Wide Dealer Coverage

...And that’s just for starters...so how about bringing us your real world problem today? Call us now at 203-647-0220.

CADKEY 3
Power...Performance...Price
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.

Ultra High-Resolution Slide Maker

The Rascoal 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 pro-
The SmarTerm Theory of Software Evolution
What Really Happened to the Dinosaurs?

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After you've tried SmarTerm terminal emulation software, you'll think other PC-to-minicomputer communications links are as advanced as . . . dinosaurs.

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NEW! SmartMOVE combines power, ease-of-use, error-free file transfer and exact DEC VT100 emulation in one "smart" communications software buy!

SmarTerm and SmartMOVE are available through your local dealer. If you would like more information about SmarTerm or SmartMOVE, circle the appropriate reader service number below. Or contact:

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Phone (608) 273-6000
Fax (608) 273-8227
Telex 759491

VISIT BOOTH 3244 WEST HALL COMDEX/ATLANTA

SmarTerm Terminal Emulation Software
. . . The Natural Selection

When you want to talk computers...

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|-------------------| | Panasonic Business Partner from $799.00 |
| Includes: A2000, 1Mb RAM, 3½" Floppy, A1080 Monitor, Mouse, DOS, A2088, Bridge Board | | Toshiba 1100 Plus ........... from $1699.00 |
| $1999 | | |

| Atari 1040 | | PC-T00 20 Meg |
| Color System | | XT-Compatible |
| $879 | | $999 |
| Includes: 1040ST, 1mb RAM with 3½" drive built-in, 192K ROM with TOS, Basic, Logo, ST language, power supply and color monitor. | | |

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When you want to talk price.

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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.

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 and uses 80K 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.
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-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.

continued
PERSONAL VOICE MAIL

"Hello. I'm not available right now. Please wait for the tone and leave a detailed message. Touch the star to listen to what you've recorded."

PERSONAL MESSAGES FOR FREQUENT CALLERS

"Hello, I'm not at work today. 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 available today. 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."

A nswering machines are irritating because they are so dumb. Even the best of them. For only $349, we'll give you personal voice mail for your PC, and turn it into the world's smartest answering machine. All without disturbing whatever else you've been doing on the PC.

How smart is "smartest?" The examples above . . . uh . . . speak for themselves. Sure, your PC can answer the phone in your voice, and let you retrieve messages remotely from any touch-tone phone. And it can call you to deliver your messages.

But give your friends and associates their own voice mailboxes. The ability to interrupt your greeting and start recording immediately. To deliver messages to each other as well as to you. The ability to transfer to other extensions. Even let them change their minds and their messages. Give them all this and you'll never again have to apologize for making people talk to a machine.

In your business, it will relieve your secretary of the burden of taking routine messages. And relieve you of the burden of transposed telephone numbers. In business or in personal use, it works 24 hours a day. Without irritating your callers like mere answering machines do. All while you're running your spreadsheet, word processor or just about anything else.

We call the world's smartest answering machine "CAM" For Complete Answering Machine. We call ourselves The Complete PC. And CAM is just the beginning of a whole line of smart products designed to help you get more from your personal computer.

You should call (800) 634-5558 today for the name of the CAM dealer nearest you.

So tomorrow, you can give your old answering machine to someone who doesn't mind annoying people.
QuickBASIC 3.0

Microsoft has upgraded QuickBASIC to version 3.0 with a faster compiler, improved debugging, and inline support for the 8087 and 80287 math coprocessors. The enhanced debugger is based on the CodeView debugger 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 overwrite modes and it's compatible with SuperKey, ProKey, and SideKick. QuickBASIC 3.0 offers BASIC compatibility and supports graphics statements, sound statements, andEGA 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 3¼-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

Turbo Pascal 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 multi-window 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 override 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 06906, (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.
WHY LOGITECH MODULA-2 IS MORE POWERFUL THAN PASCAL OR C.

APPRENTICE PACKAGE $99
- Separate Compilation
- Native Code Generation
- Large Memory Model Support
- Most Powerful Runtime Debugger
- Comprehensive Module Library
- Maintainability
- Translator from Turbo and ANSI Pascal

NEW!
- **APPRENTICE PACKAGE** $99
  Everything you need to begin producing reliable maintainable Modula-2 code. Includes the Compiler with 8087 support, integrated Editor, Linker, and BCD Module. We’re also including FREE our Turbo Pascal to Modula-2 Translator!

NEW!
- **WIZARDS’ PACKAGE** $199
  This package contains our Plus Compiler—for professional programmers or for those who just want the best. The Plus Compiler with Integrated Editor requires 512K and takes advantage of the larger memory to increase compilation speed by 50%. Our Turbo Pascal to Modula-2 Translator is also included at no extra charge.

NEW!
- **MAGIC TOOLKIT** $99
  We’ve put our most powerful development tools into one amazing Toolkit for use with either the Apprentice or Wizards’ packages. Highlighted by our Runtime Debugger, the finest debugging tool available anywhere, the Toolkit also includes our Post Mortem Debugger, Disassembler, Cross Reference utility and Version which keeps track of different versions of one program. Our MAKE Utility figures out module dependencies and automatically selects those affected by code changes to minimize recompilation and relinking. We also provide source code of our major library modules for you to customize—or just play with.

NEW!
- **WINDOW PACKAGE** $49
  Now you can build true windowing into your Modula-2 code. Features virtual screens, color support, overlapping windows and a variety of borders.

NEW!
- **ROM PACKAGE AND CROSS RUN TIME DEBUGGER** $299
  For those who want to produce rommable code. You can even debug code running in ROM from your PC.

WIN A FREE TRIP TO Switzerland

HOME LAND OF MODULA-2
Return your Module-2 Registration Card or a reasonable facsimile* postmarked between March 1, 1987 and May 31, 1987 to be included in a once-only drawing!

Grand Prize: One week excursion for 2 in Zurich, Switzerland including a guided tour of ETH, the University where Modula-2 was created by Niklaus Wirth. European customers may substitute a trip to Silicon Valley, California.

Second and Third Prizes: LOGITECH C7 Mouse or LOGITECH Bus Mouse with Paint & Draw software—a $219 value, absolutely free!

*Write to Logitech, Inc. for a registration card facsimile.

Call for information about our VAX/VMS version, Site License, University Discounts, Dealer & Distributor pricing.
To place an order call toll-free:
800-231-7717
In California:
800-552-8885

YES! I want the spellbinding power of LOGITECH Modula-2!
- Apprentice Package $99
- Wizards’ Package $199
- Magic Toolkit $99
- Window Package $49
- ROM Pkg/Cross RTD $299

Add $6.50 for shipping and handling, Calif. residents add applicable sales tax. Prices valid in U.S. only.
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In Italy:
Tel: 39-2-215-5622

JUNE 1987 • BYTE 61

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.


Inquiry 608.

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.

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
LOGITECH C7 MOUSE
$99

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

At LOGITECH we've spent years perfecting our high-quality mouse hardware and software. And every LOGITECH Mouse reflects the engineering we've devoted to it.

MAXIMUM COMPATIBILITY
The programmable LOGITECH Mouse works with virtually ALL hardware and application software.

BEST MOUSE TECHNOLOGY
The opto-mechanical LOGITECH Mouse offers the best of all worlds. Mechanical tracking (a ball) and optical decoding (precise, reliable optical encoder). Every major computer manufacturer, including Apple, IBM and DEC, has chosen opto-mechanical mouse technology. LOGITECH offers the only opto-mechanical mouse on the retail market.

BEST MOUSE FOR GRAPHICS & CAD
High (200 dot per inch) resolution, precise tracking, and a 3-button design are essential for graphics and CAD.

BEST MOUSE FOR DESKTOP PUBLISHING
Ergonomic styling is a must for all mouse-intensive desktop publishing applications. High resolution is essential for high-resolution screens.

BEST MOUSE FOR SPREADSHEETS & WORD PROCESSING
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!

BEST MOUSE SOFTWARE
"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.

LOGITECH BUS MOUSE
$149 with LogiPaint
100% Microsoft Bus Mouse Compatible! It has all the features of the LOGITECH C7 MOUSE, plus it leaves the serial port on your computer free for other peripherals. It comes standard with our-top-of-the-line Plus Software and LogiPaint.

NEW!

LOGITECH BUS MOUSE
$149 with LogiPaint

BEST DEALS
We offer either our C7 or Bus mouse, with Plus software, packaged with some of the most exciting applications on the market, at very exciting prices.

LOGIPOINT Special Offer! $149
The LOGITECH Mouse with PC Paintbrush is the most advanced paint set available for the PC. It offers 11 type fonts, a pallet of 16 colors, and the ability to import and embellish files from other applications.

LOGICADD $189
The LOGITECH Mouse packaged with Generic CADD and Dot Plot turns your PC into a complete CADD workstation. Generic CADD offers the features and performance of high priced CADD at an unbelievably low price. DotPlot is the add on utility that enables you to produce crisp, high resolution drawings from your dot matrix printer.

LOGIPOINT & DRAW $219
The LOGITECH Mouse packaged with LOGIPOINT and LOGICADD. Together they are the complete graphics toolkit for combining freehand and technical drawings.

LOGITECH C7 Mouse w/Drivers $99
LOGITECH C7 Mouse w/Plus Software $119
LOGITECH BUS Mouse w/Plus Software and LogiPaint $149
Additional Software (with C7 and Plus or Bus Mouse and Plus.)
LOGIPOINT $149
LOGICADD $189
LOGIPOINT & DRAW $219
Add $5.50 for shipping and handling, Calif. residents add applicable sales tax. Prices valid in U.S. only.

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30-Day Money-Back Guarantee/3-Year Warranty

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JUNE 1987 • BYTE 63

Inquiry 169 for End-Users. Inquiry 170 for DEALERS ONLY.
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 subtotals. 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.

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 output to MIDI-compatible keyboards and instruments as well as to the SuperSonic stereo card from MDI Ideas 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.
TEKTRONIX NEW ADVANCED PC GRAPHICS STANDS ALONE.
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.

refresh rate. So you can use advanced packages like AutoCAD, Zenographics'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

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
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
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


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

EVENTS AND CLUBS

June 1987

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

ROBEX '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) 799-6555. 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. Theipei World Trade Center, 201 Tunhwa North Rd., Taipei 10591, Taiwan, Republic of China, (02) 715-1515. June 8-14


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


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


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


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

International Computing Association (ICA), c/o Markus H. Maegge, 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.


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.

Inquiry 309

JUNE 1987 • BYTE 65
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.

Now the InColor Card gives you the same high resolution 720x348 graphics in up to 16 colors using an IBM Enhanced Color Display, multisync 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.

**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.

Remember, only the InColor Card has color-to-monochrome compatibility, high resolution text and graphics, and the power of color RamFont.

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

---

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

---

**The New Hercules InColor Card.**

---

Hercules Computer Technology, 2550 Ninth St., Berkeley, CA 94710 Ph: 415 540-6000 Telex: 754063 Fax: 415 540-6821 Trademarks/Owner: Hercules, InColor, RamFont/Hercules; Lotus, 1-2-3, Symphony, Manuscript/Lotus, Microsoft/Microsoft; AutoCAD/AutoDesk; IBM/IBM

Inquiry 129 for End-Users. Inquiry 130 for DEALERS ONLY. JUNE 1987 • BYTE 67
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; is this 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 setup 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.

The Oberon was a bit different than what I expected. After some time, I discovered that the unit is very portable and easy to use. I think it could be very useful for people who need to read text quickly and accurately. I would recommend it to anyone looking for a good OCR system.

Second, I recently came across a new machine that is revolutionizing the way we do business. It's called the Space Station and it is designed for use in space stations. It is a fully automated system that can perform all sorts of tasks, from basic maintenance to complex operations. I think it could be a great addition to our company's fleet of machines.

If you have any questions or would like more information about these machines, please feel free to contact me.
News about the Microsoft Language Family

New Microsoft® QuickBASIC 3.0 Includes Integrated Debugger and Editor Enhancements

It's hard to improve on a great product like Microsoft QuickBASIC, but we've added and enhanced features in Version 3.0 that make developing programs faster and easier than ever. Integrated debugger enhancements let you pinpoint errors by tracing or animating through your source code. Now you can observe the contents of your program's variables as the program is running. And set dynamic breakpoints at runtime to easily stop the program where you want. You don't have to add STOP statements to your programs and wait for another compilation anymore. With the debugger completely integrated into the compiler, you can start debugging your program while it's running simply by pressing CTRL-BREAK.

Microsoft QuickBASIC's built-in editor has been enhanced to support overtype as well as the existing insert mode so editing your programs is easier. In contrast to other compilers that give up after finding a single error, Microsoft QuickBASIC keeps track of all errors found during compilation. You can correct all the errors at once instead of recompling for each error. The Microsoft QuickBASIC Version 3.0 editor is compatible with SuperKey®, ProKey™, and SideKick® programs.

As in Version 2.0, Microsoft QuickBASIC 3.0 supports multiple-module programming. Separate compilation lets you divide your program into pieces that are compiled independently. These pieces can be integrated into other BASIC programs without recompilation. The linker in Microsoft QuickBASIC makes it easy to add Microsoft Macro Assembler object files to your BASIC programs. Just assemble your Microsoft Macro Assembler routines and let the linker incorporate them into Microsoft QuickBASIC automatically. There's no need to convert your Microsoft Macro Assembler routines into COM files or write them as hexadecimal numbers in your BASIC source file as in other compilers.

Math Coprocessor Support in Microsoft QuickBASIC 3.0 Speeds Programs

Microsoft QuickBASIC now has support for the 8087 and 80287 math coprocessors. The full 80-bit IEEE math support of the math coprocessor is needed for programs that demand the most precise calculations. In addition to this, you may use the existing Microsoft Binary Math support for fast 64-bit math or the new 8087 emulation routines for more accuracy when you don't have a coprocessor.

There have also been many dramatic speed enhancements in Microsoft QuickBASIC 3.0, especially in graphics and math. For example, Version 3.0 is 118% faster than Version 2.0 for circles. And with 8087/80287 math coprocessor support, the floating-point math is 160% faster than in Version 2.0.

New Microsoft QuickBASIC Language Extensions Make Programs Easier to Read

A number of new control structures such as SELECT CASE, DO WHILE, DO UNTIL, LOOP WHILE, LOOP UNTIL, and EXIT have been added to Microsoft QuickBASIC 3.0. These statements are similar to those found in Microsoft C and Microsoft Pascal. These statements, in addition to the block IF/THEN/ELSE/END IF (which was incorporated in Version 2.0), make structured programming easier.

The new named constants make your programs more readable and easier to maintain. Subprograms and multi-line functions have true local variables and allow you to call them by name and pass them parameters. These C-like structures let you write programs that are more well organized.

For more information on the products and features discussed in the Newsletter, write to Microsoft Languages Newsletter 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. Or phone: (800) 426-9400. In Washington State and Alaska, call (206) 882-8088. In Canada, call (416) 673-7638

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CHOICE OF THE CRITICS!

"UNLock has two particularly endearing characteristics: it works, and worst simply. I was able to quickly produce unprotected copies of Lotus 1-2-3 Release 2, Symphony 1.1, Microsoft Word 2.0, dBase III 1.1, and Framework II. These copies performed flawlessly, as did copies of these copies."

Christopher O'Malley
PERSONAL COMPUTING, April '86

"Because copy protection can interfere with the ability to back up a hard disk, business-oriented users may prefer programs like TranSec's UNLock series."

Winn L. Rosch, PC MAGAZINE, MAY 27, 1986

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 OmniReader, 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, Texas 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 interface card 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
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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 LOAD 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
It's moving day.

Time to pack up that big mainframe program and move it to the PC.

Relax. It's going to be the easiest move you ever made if you use the new RM/FORTRAN™ V2.4 with Ryan-McFarland's new RM/Forte™ productivity tools.

RM/FORTRAN has the VAX, VS and FORTRAN-66 extensions you need, and is field-proven with more than two years of mainframe conversions by thousands of demanding engineers and scientists.

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**CIARCIA FEEDBACK**

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

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Musical Floppies

Thanks for your suggestion for a Circuit Cellar project. OKI Semiconductor in Sunnyvale, California, has recently announced the MSM6258 speech-processing 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-...
WHO YA GONNA CALL?

BUGBUSTERS!

"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 is that 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.

The AT PROBE is a debugging tool that plugs into your PC AT and monitors everything the processor is doing. In real time.

REAL TIME DEBUGGING.

SOONER OR LATER, YOU KNOW YOU’LL NEED IT.

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.

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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.

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CIARCIA FEEDBACK

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
Enter the world of professional CAD applications with Houston Instrument's low cost DMP-41/42 series plotters. These single-pen plotters give you the features you need—C and D size plots, extensive software compatibility, and proven reliability—for a very affordable no frills price of $3295.*

The DMP-41/42 series' large C and D size formats are ideal for a wide range of CAD applications, from architectural elevations to assembly drawings. And a .005 inch resolution ensures crisp drawings on a variety of media—paper, matte film, or vellum.

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Now you can bridge the operating systems gap with CYB Systems’ UNITE. UNITE’s unique connective power lets you develop and use software with total compatibility and flexibility between MS-DOS, PC DOS and/or UNIX operating environments.

With UNITE, you can boost your productivity and end the isolation of PC stations, departments and work groups by moving data between disparate operating systems and machines. Single function keystrokes enable you to process work on a PC, suspend operations and transfer files locally or to remote stations, access 3270 mode, or act as a UNIX terminal with all utilities. UNITE also provides an on-board upward link to popular mainframes via TCP/IP or SNA protocols. And with UNITE you can add greater interconnective capabilities for true departmental processing further up the road.

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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 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.
In 1981, we introduced the world's most successful personal computer.

Here we go again.
Five years ago, we sent our first personal computer out the door and hoped you'd find it useful.
We're pleased you did.
Over three million IBM® PCs have been put to work, doing everything from financial analysis to first-grade arithmetic.
Yet as PCs grew more popular, and as we kept improving them, one thing became clear. You needed more.
You're in a hurry, so you want PCs to respond faster.
You do many things at once and wish your PCs could too.
You want software that's more powerful, but also easier to use.
You'd like more color.
You're eager for your systems to communicate with other systems.
You want improved reliability.
And you want all this without obsoleting your investment in equipment, software and training.
So there was only one thing we could do: create a whole new system for personal computing.
The new IBM Personal System/2.
Its heart is a new line of hardware and software, but its soul is bigger; new technology, of course, but also a new "balanced system" approach for making things work together.
It works with earlier IBM PCs so your investment is protected. It works with larger IBM systems so your future growth is protected. It works for business and education, for professional people of every stripe.
The next generation in

The new systems.
There are four models of the new IBM Personal System/2: Models 30, 50, 60 and 80, with a choice of configurations, with new design and components, and built not merely for speed but for well-balanced performance.

**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...
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.

The new performance. You’ll find new architecture, new

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.

IBM Personal System/2 Model 60

IBM Personal System/2 Model 80

integrated design and new operating systems that together lift raw power to higher levels of true performance, while cost goes the other way.

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.

**The new connectivity.**

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 new support.**

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.
Introducing the IBM Personal System/2
So, it’s power you want.

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.

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...
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 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 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.

*A bigger idea.* Operating System/2 is also part of another new idea, called IBM System 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 256,000 colors 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.

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...
sharp and clearly defined. **Better letters.**

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

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).

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

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

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

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

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.

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...
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.

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.
The solution is part of the 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.

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

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

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

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"
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.

Earlier IBM Quietwriter printers have always been

*Based on an independent evaluation using PC Magazine Labs Benchmark Series.
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from a special kind of dealer. Introducing the new IBM Authorized Advanced Products Value Added Dealers.

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A system that's bigger sum of its parts.

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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.

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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.

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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.

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

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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.

<table>
<thead>
<tr>
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<th>Model 30</th>
<th>Model 50</th>
<th>Model 60</th>
<th>Model 80</th>
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<td>8086</td>
<td>80286</td>
<td>80286</td>
<td>80386</td>
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<tr>
<td><strong>Potential system throughput</strong></td>
<td>Up to 2 1/2 times PC/XT</td>
<td>Up to 2 times Personal Computer AT</td>
<td>Up to 2 times Personal Computer AT</td>
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<td>20MB</td>
<td>44, 70MB</td>
<td>44, 70, 115MB</td>
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<td>70, 115MB</td>
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<td>PC DOS 3.3</td>
<td>PC DOS 3.3 and Operating System/2</td>
<td>PC DOS 3.3 and Operating System/2</td>
<td>PC DOS 3.3 and Operating System/2</td>
</tr>
</tbody>
</table>

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.

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Printed in the USA 0360-2757-00
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...
**Expansion Chassis/Tape Backup**

### Specification

<table>
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<tr>
<th>Model</th>
<th>No. of Slot</th>
<th>Space (W x D x H)</th>
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<tr>
<th>Demo package</th>
<th>Manual only</th>
<th>AMX86 system</th>
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<tr>
<td>$25 US</td>
<td>$75 US</td>
<td>$2195 US</td>
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**BOOK REVIEWS**

"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 Britain'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
### Software

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### Spreadsheets/Integrated Packages

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*CALL FOR SHIPPING COSTS*
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, modules, 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

```plaintext
CASE character OF
    'A': Write('Vowel');
    'X': Write('Consonant');
    'O': 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.

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.
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BOOK REVIEWS

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 Lodgard 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 inifinities 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 impractically 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:

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BOOK REVIEWS

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.
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BOOK REVIEWS

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 sys­
tem. 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 sys­
tem, too many of which are now proudly proclaimed as "rela­
tional." 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 de­
sign and implementation. Of interest here is the observation that
the services of a 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 en­
hancements 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 cor­
responding 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 suc­
ceed simultaneously in three areas—application code (distri­
buted 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 every­
one 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 pro­
gram 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 develop­
ment 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, ex­
ample of DBMS design as a fruitful field for integrating differ­
ent 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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FIRST IMPRESSIONS:
The IBM PS/2 Computers

The Personal System/2—including a 32/16-bit bus, new operating systems, and new graphics systems—redefines IBM’s microcomputer standards

The timing was almost perfect: Just weeks after Apple launched the 68020-based Mac II, establishing a new standard that will dominate Apple products for some time to come, IBM announced an entire new line of personal computers (complete with a different bus and two new operating systems) that might similarly set the standard for 80x86-based systems.

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 Wsola. 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...
The IBM Personal System/2 Computers.

From left to right, the Models 80, 50, 30, 60.
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 3 1/2 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 8514A.

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

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

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 is 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 drive.
8. The Model 60 also 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 Model 80 has 8 slots, 3 of which can be used by either 16- or 32-bit boards. One 16-bit slot is used by the hard disk.
10. 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.
11. 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:

<table>
<thead>
<tr>
<th>IBM's PS/2 Model 80-041</th>
<th>Apple's Mac II Model HD40</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-MHz 80386</td>
<td>16-MHz 68020</td>
</tr>
<tr>
<td>1 megabyte of RAM</td>
<td>1 megabyte of RAM</td>
</tr>
<tr>
<td>1.44-megabyte floppy</td>
<td>800K-byte floppy</td>
</tr>
<tr>
<td>44-megabyte hard disk</td>
<td>40-megabyte hard disk</td>
</tr>
<tr>
<td>3 open 32-bit slots</td>
<td>5 open 32-bit slots</td>
</tr>
<tr>
<td>4 open 16-bit slots</td>
<td>keyboard</td>
</tr>
<tr>
<td>keyboard</td>
<td>video card</td>
</tr>
<tr>
<td>video card</td>
<td>68881 coprocessor</td>
</tr>
<tr>
<td>system software</td>
<td>13-inch color monitor</td>
</tr>
</tbody>
</table>

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 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 of 256K 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 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
The Diconix 150. Take it or leave it.
The world’s most portable printer performs as well at your desk as it does when you’re on the road. The small footprint reduces desktop clutter, while it enlarges a small budget.
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 2 1/2 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 F4 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.

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 11 1/2-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
**Key**

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

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

---

**Figure 1:** The Micro Channel slot pin-outs.
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 –PRE-EMPT, 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-
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But this is just half the story.
mates 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...
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 continue
Introducing the revolutionary new 1/4-inch cartridge from DEI. Series II Gold."

You think nothing lasts forever? Think again.

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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:

<table>
<thead>
<tr>
<th>IBM word</th>
<th>Real-world definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>adapter</td>
<td>peripheral card</td>
</tr>
<tr>
<td>channel</td>
<td>bus</td>
</tr>
<tr>
<td>facility</td>
<td>usually a combination of hardware and software</td>
</tr>
<tr>
<td>feature</td>
<td>a hardware add-in, usually a peripheral card or a disk drive</td>
</tr>
<tr>
<td>fixed disk</td>
<td>hard disk</td>
</tr>
<tr>
<td>pel</td>
<td>pixel</td>
</tr>
<tr>
<td>planar</td>
<td>motherboard</td>
</tr>
</tbody>
</table>

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).
Who said you can not print graphics with a daisy wheel printer! Primages once again uses advanced technology to bring a new dimension to Office Automation printing. The Primages 90-GT “Daisygrapher” emulates the Epson FX-80** Graftrax** (bitmap graphics mode). This allows graphic images to be printed within fully formed text fields—real letter quality that only a daisy wheel printer will allow, taking full advantage of the ever increasing sophistication of Office Automation applications. This is in addition to the standard Diablo 630* emulation...both are now standard and all this at 90 characters per second!

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Microsoft's New DOS

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 3¼-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.
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.
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 (dy- links, for short).

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 21 hs 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-

![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.](image-url)

continued
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 unprotected 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 application 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.

by Gordon Letwin
Inquiry 343

NEW DOS

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...
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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 \( \pi \) 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 \( \pi \) 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.

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 semaphore 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.
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compatibility bridge between the two sides of OS/2, giving products an easy way to migrate to OS/2's protected area.

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 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 programs 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...
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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 dynamic-link references that must be satisfied at load time and passes control to the program.

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 version of the operating system. 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.

![Diagram of the new .EXE file format](image)

- Old .EXE header
- Offset to new .EXE header
- Stub loader
- Library routines
- New .EXE header
- Program
- Dyna-link references

include the Apple II GS, 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 ROM); 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 XT's 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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Build a Gray-Scale Video Digitizer

An imaging system with remarkable features for the price

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.

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.

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-
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.
Signals 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 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.
A flash A/D converter differs from slower converters in having more internal circuitry.

remaining 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 $+V_{cc}$ and $-V_{cc}$. 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 ($+V_{cc}$) and black ($-V_{cc}$) 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.

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 28.8 kbps

16-line vertical delay
Compression enabled
Ignore +/−1 count changes
Packed 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
Table 1: ImageWise digitizer/transmitter DIP-switch settings. ON and OFF refer to switch positions.

<table>
<thead>
<tr>
<th>Switches</th>
<th>Serial bit rate (must match receiver's rate)</th>
<th>Vertical blanking delay from the first vertical sync pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3</td>
<td>300 bps</td>
<td>Switch 4 selects the vertical blanking delay from the first vertical sync pulse.</td>
</tr>
<tr>
<td>OFF OFF OFF</td>
<td>300 bps</td>
<td>OFF 16 lines (normal)</td>
</tr>
<tr>
<td>OFF OFF ON</td>
<td>600 bps</td>
<td>ON 20 lines (extended)</td>
</tr>
<tr>
<td>OFF ON OFF</td>
<td>1200 bps</td>
<td></td>
</tr>
<tr>
<td>OFF ON ON</td>
<td>2400 bps</td>
<td></td>
</tr>
<tr>
<td>ON OFF OFF</td>
<td>9600 bps</td>
<td></td>
</tr>
<tr>
<td>ON OFF ON</td>
<td>19.2k bps</td>
<td></td>
</tr>
<tr>
<td>ON ON OFF</td>
<td>28.8k bps</td>
<td></td>
</tr>
<tr>
<td>ON ON ON</td>
<td>57.6k bps</td>
<td></td>
</tr>
</tbody>
</table>

(Note: 4800 bps was intentionally omitted.)

Switch 5 enables or disables picture compression.

<table>
<thead>
<tr>
<th>Switch 5</th>
<th>Run-length encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF ON</td>
<td>disabled (no compression)</td>
</tr>
<tr>
<td>ON ON</td>
<td>enabled (compression)</td>
</tr>
</tbody>
</table>

Switch 6 enables or disables the \( +/− 1 \) count change compression.

<table>
<thead>
<tr>
<th>Switch 6</th>
<th>Compress ( +/− 1 ) count changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF ON</td>
<td>encode (less compression)</td>
</tr>
<tr>
<td>ON ON</td>
<td>ignore (more compression)</td>
</tr>
</tbody>
</table>

(Note: Switches 7 and 8 are not used and must be OFF.)
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.

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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.

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 videophone. 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, "telemaging" 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

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**Table 2: Hayes Smartmodem DIP-switch settings for use with the ImageWise system.**

<table>
<thead>
<tr>
<th>Switch</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DOWN</td>
<td>Smartmodem DTR input on pin 20 is forced active.</td>
</tr>
<tr>
<td>2</td>
<td>UP</td>
<td>Don't care, UP for English responses to commands.</td>
</tr>
<tr>
<td>3</td>
<td>UP</td>
<td>Suppress responses to commands.</td>
</tr>
<tr>
<td>4</td>
<td>DOWN</td>
<td>Do not echo characters.</td>
</tr>
<tr>
<td>5</td>
<td>UP</td>
<td>Smartmodem will auto-answer on first ring.</td>
</tr>
<tr>
<td>6</td>
<td>UP</td>
<td>Don't care, UP for CD when carrier detected.</td>
</tr>
<tr>
<td>7</td>
<td>UP</td>
<td>Single line phone connection.</td>
</tr>
<tr>
<td>8</td>
<td>UP</td>
<td>Disable Smartmodem command recognition.</td>
</tr>
</tbody>
</table>

**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).
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

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**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.
#1 C interpreter

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C-terp 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 diskette, 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 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 08620.


The following items are available from

- **CCI**
  - P.O. Box 428
  - Tolland, CT 06084
  - (203) 875-2751

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.
   - **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 an 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
   - **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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Inquiry 338
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

![Figure 1: Contour maps of a mathematical function (a) described in the text and of equipotential fields (b) around two charge particles.](image-url)
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, 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 \((x_1, y_1), (x_{i+1}, y_1), (x_i, y_{i+1}), (x_{i+1}, y_{i+1})\). 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.

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 I.

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 I, 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Intersection of triangle and the contour plane</th>
<th>Point locations with respect to the contour plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Line through one side of the triangle</td>
<td>1 above, 2 on plane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 below, 2 on plane</td>
</tr>
<tr>
<td>II</td>
<td>Line bisecting the triangle through one vertex</td>
<td>1 above, 1 below, 1 on plane</td>
</tr>
<tr>
<td>III</td>
<td>Line bisecting the triangle through two sides</td>
<td>1 above, 2 below plane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 above, 1 below plane</td>
</tr>
<tr>
<td>IV</td>
<td>No intersection</td>
<td>3 above plane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 below plane</td>
</tr>
<tr>
<td>V</td>
<td>Point intersection</td>
<td>2 above, 1 on plane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 below, 1 on plane</td>
</tr>
<tr>
<td>VI</td>
<td>Plane intersection</td>
<td>3 on plane</td>
</tr>
</tbody>
</table>

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 1ub, jub 'Index bounds of the data array
REM x(0:jub) '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
REM conrec:
REM Local declarations for CONREC
DIM h(4) 'Relative heights of the box above contour
DIM ish(4) 'Sign of h( )
DIM xb(4) 'x coordinates of box
DIM yh(4) 'y coordinates of box
DIM lm(3) 'Mapping from vertex numbers to x offsets
lm(O)=0 : lm(1)=1 : lm(2)=1 : lm(3)=0
DIM jm(3) 'Mapping from vertex numbers to y offsets
jm(O)=0 : jm(1)=0 : jm(2)=1 : jm(3)=1

continued
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### Listing 1: continued.

```plaintext
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 (noc<=0) THEN prmerr=true
FOR k=1 TO n-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,j+1)<dmin) THEN dmin=d(i,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,j+1)>dmax) THEN dmax=d(i,j+1)
IF (dmax<=z(0) OR dmin>=z(n-1)) THEN GOTO noneinbox
REM Draw each contour within this box
FOR k=0 TO n-1
IF ((z(k)<dmin) OR (z(k)>dmax)) THEN GOTO noneintri
FOR m=4 TO 0 STEP -1
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 easel, 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 n2-n3
case4: x1=xh(m1) : y1=yh(m1)
x2=(h(m2)*xh(m2)-h(m3)*xh(m3))/(h(m2)-h(m3))
y2=(h(m2)*yh(m2)-h(m3)*yh(m3))/(h(m2)-h(m3))
GOTO drawit
REM Line between vertex m2 and side n2-n3
case5: x1=xh(m2) : y1=yh(m2)
x2=(h(m1)*xh(m1)-h(m3)*xh(m3))/(h(m1)-h(m3))
y2=(h(m1)*yh(m1)-h(m3)*yh(m3))/(h(m1)-h(m3))
GOTO drawit
REM Line between vertex m3 and side n1
```
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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 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.

Listing 3: A QuickBASIC example program to draw the contour map shown in figure 1b.

A QuickBASIC example program. Graph the equipotential lines.

| 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 |
| 1x=x+i*ilength/iub \ Range from -4 to 4 |
| FOR j=0 TO jub |
| jy=y+j*jlength/jub \ Range from -4 to 4 |
| r1=SQRT((i+1)*i+1*j+1)*j+1 \ Distance from grid point |
| r2=SQRT((i+1)*i+1*j+1)*j+1 \ Distance from grid point |
| (i,j) \ Coordinate pair |
| NEXT j |
| x(i)=i*ilength/jub+i \ Scale x(i) to span plot area |
| NEXT i |

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 the CONREC subroutine to the main program, and you are ready to begin making your own contour maps.

Listing 4: The QuickBASIC VECOUT subroutine for plotting a line segment on the screen.

| REM User defined subroutine to plot vectors on whatever plotting device is available |
| SUB vecout(xstart,ystart,xstop,ystop,level) STATIC |
| LINE (xstart,ystart)-(xstop,ystop) END SUB |
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Polynomial Curve Fitter

This BASIC program finds a polynomial function to fit a set of data points

**William G. Hood**

**Programming Insight**

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 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.

The function would allow you to extrapolate (predict results outside the measurement range) or interpolate (predict results outside 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

\[ p(x) = c_0 x^n + c_1 x^{n-1} + \ldots + c_n x + c_{n+1} \]

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; \( c_1, c_2, \ldots \) 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 independent 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 points.
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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 FNMM(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: X=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=MKM THEN J1=M+1: MM=M: GOTO 1130
1080 J1=1: MM=0: S1=0: S2=0: S3=0: S4=0
1090 FOR I=1 TO N: WT=W(I)
1100 Sl=Sl+WT*X(I): S2=S2+WT: SJ=SJ+WT*Y(I): S4=S4+WT*Y(I)*Y(I)
1110 NEXT I
1120 D4(1)=Sl/S2: D5(1)=0: D6(1)=SJ/S2: D1(1)=0: D2(1)=1: VR=S4-SJ*D6(1)
1130 FOR J=1 TO MM: Sl=0: S2=0: SJ=0: S4=0
1140 FOR I=1 TO N: Pl=0: P2=1
1150 FOR K=1 TO J: P=P2: P2=(X(I)-D4(K)*P2-D5(K)*Pl: Pl=P: NEXT K
1160 WT=W(I): P=P*WT*P2*P2
1170 Sl=Sl+P*X(I): S2=S2+P: SJ=SJ+WT*P1*Pl: S4=S4+WT*Y(I)*P2: NEXT I
1180 D4(J+1)=Sl/S2: D5(J+1)=SJ/S2: D6(J+1)=S4/S2:
1190 D1(J+1)=D4(J)*D2(J)-D5(J)*D1(J)
1200 IF J>1 THEN 1210
1210 FOR K=2 TO J-2: DJ(K)=D2(K-1)-D4(J)*D2(K)-D5(J)*D1(K): NEXT K
1220 IF J>3 THEN 1210
1230 FOR K=1 TO J: D1(K)=D2(K): D2(K)=DJ(K): D6(K)=D6(K)+DJ(K)*D6(J+1)
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: PI=C(I)
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: NEXT I
1290 S2=0: IF N+M+1 THEN S2=S2/10
1300 R2=1: IF VR<>0 THEN R2=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 NF=0 if new data, NF=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 DLS
1460 PRINT "Polynomial. Copyright (C) 1986 by William G. Hood"
1470 PRINT
1480 PRINT "This program finds the coefficients of the nth degree polynomial."
1490 PRINT "Y=c(1)x^n+c(2)x^(n-1)+...+c(n)x+c(n+1)
1500 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): "; FILE
1570 PRINT "Is the data weighted (Y/N, null line=No)? "; W$=1: INPUT W$
1580 IF W$="Y" THEN 1600: IF W$="N" THEN 1600
1590 IF W$="Y" THEN 1600: IF W$="N" THEN 1600
1600 IF FILE<>0 THEN 2000
```
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CONTINUE

In practice, the largest degree is typically
a polynomial approximation; the pro­
fit. But this is not usually the case. For
large values of n, it is not practical to find
a polynomial that you can use to determine which de­
ance is the sum of squares divided by the
degree gives the best fit. The residual vari­
tion, yet low enough so that it “averages
out” errors in the data. The program pro­
to find which degree gives the best fit,
residual variance,
degree high enough that the poly­
omial will come close to the true func­
yet low enough so that it “averages
out” errors in the data. The program pro­
to find which degree gives the best fit,

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<k<\"N\" THEN PRINT \"x,y,w;\" x(K),y(K),W(K): W(K)=ABS(W(K))
1660 IF \"N\" THEN PRINT \"x,y,\" x(K),y(K): W(K)=1
1670 NEXT K
1680 PM=PM1(1D-1,N-1)
1690 PRINT \"Degree of polynomial (1<=m <= \" PM\")\"; INPUT M: N=INT(M)
1700 IF N<OR M>PM THEN 1690
1710 BTSUB 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 B2=INT(1000000-W2+5)/1000000
1770 PRINT: PRINT \"Coefficient of determination: \"; R2
1780 PRINT \"Try another degree (Y/N, null line=No) \"; AS=\"Y\"; INPUT AS
1790 IF \"N\" THEN 1690
1800 PRINT \"Print a table of the data (Y/N, null line=No)\"; AS=\"Y\"; INPUT AS
1810 IF \"Y\" AND AS<\"y\" THEN 1780
1820 PRINT: PRINT \"Degree of polynomial \"; M
1830 PRINT: PRINT \"X\"; TAB(11) \"Y\"; TAB(25) \"p(x) \n1840 FOR I=1 TO N: P=C(I)
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 FB<>NOB THEN END
1880 PRINT: PRINT \"Save the data (Y/N, null line=No) \"; AS=\"N\"; INPUT AS
1890 IF \"Y\" AND AS<>\"y\" THEN END
1900 PRINT \"Writing to \"; FILE","; AS=\"Y\"; INPUT AS
1910 IF FB<>NOB THEN END
1920 PRINT \"Writing to \"; FILE","; AS=\"Y\"; INPUT AS
1930 OPEN FILE FOR OUTPUT AS 1
1940 FOR I=1 TO N
1950 IF W<k<\"N\" THEN PRINT#1, X(I);\"; \"Y(I);\"; W(I)
1960 IF \"N\" THEN PRINT#1, X(I);\"; \"Y(I)
1970 NEXT I
1980 CLOSE 1
1990 END
2000 PRINT \"Reading from \"; FILE
2010 OPEN FILE FOR INPUT AS 1
2020 N=0
2030 PRINT \"X\"; TAB(15) \"Y\"; TAB(28) \"\n: PRINT
2040 IF EOF(1) OR N=LN THEN 2100
2050 N=N+1
2060 IF W<k<\"N\" THEN PRINT#1, X(N),Y(N),W(N): W(N)=ABS(W(N))
2070 IF \"N\" THEN PRINT#1, X(N),Y(N): W(N)=1
2080 X(N) TAB(14) Y(N) TAB(28) W(N)
2090 GOTO 2040
2100 CLOSE 1
2110 PRINT \"File contained \"; N; \" data points.\"
2120 IF N<2 THEN PRINT \"Too few data points.\"; END
2130 GOTO 2040

Listing 1: continued.

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 B2=INT(1000000-W2+5)/1000000
1770 PRINT: PRINT \"Coefficient of determination: \"; R2
1780 PRINT \"Try another degree (Y/N, null line=No) \"; AS=\"Y\"; INPUT AS
1790 IF \"N\" THEN 1690
1800 PRINT \"Print a table of the data (Y/N, null line=No)\"; AS=\"Y\"; INPUT AS
1810 IF \"Y\" AND AS<\"y\" THEN 1780
1820 PRINT: PRINT \"Degree of polynomial \"; M
1830 PRINT: PRINT \"X\"; TAB(11) \"Y\"; TAB(25) \"p(x) 
1840 FOR I=1 TO N: P=C(I)
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 FB<>NOB THEN END
1880 PRINT: PRINT \"Save the data (Y/N, null line=No) \"; AS=\"N\"; INPUT AS
1890 IF \"Y\" AND AS<>\"y\" THEN END
1900 PRINT \"Writing to \"; FILE","; AS=\"Y\"; INPUT AS
1910 IF FB<>NOB THEN END
1920 PRINT \"Writing to \"; FILE","; AS=\"Y\"; INPUT AS
1930 OPEN FILE FOR OUTPUT AS 1
1940 FOR I=1 TO N
1950 IF W<k<\"N\" THEN PRINT#1, X(I);\"; \"Y(I);\"; W(I)
1960 IF \"N\" THEN PRINT#1, X(I);\"; \"Y(I)
1970 NEXT I
1980 CLOSE 1
1990 END
2000 PRINT \"Reading from \"; FILE
2010 OPEN FILE FOR INPUT AS 1
2020 N=0
2030 PRINT \"X\"; TAB(15) \"Y\"; TAB(28) \"\n: PRINT
2040 IF EOF(1) OR N=LN THEN 2100
2050 N=N+1
2060 IF W<k<\"N\" THEN PRINT#1, X(N),Y(N),W(N): W(N)=ABS(W(N))
2070 IF \"N\" THEN PRINT#1, X(N),Y(N): W(N)=1
2080 X(N) TAB(14) Y(N) TAB(28) W(N)
2090 GOTO 2040
2100 CLOSE 1
2110 PRINT \"File contained \"; N; \" data points.\"
2120 IF N<2 THEN PRINT \"Too few data points.\"; END
2130 GOTO 2040

CURVE FITTING

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 pro­
gram 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 poly­
nomial will come close to the true func­
yet low enough so that it “averages
out” errors in the data. The program pro­
to find which degree gives the best fit,
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![Image of rating scale]

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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:

\[
\begin{array}{c|c}
 x & y \\
 0.5 & 3.0 \\
 1.5 & 7.0 \\
 2.5 & 12.5 \\
 5.5 & 14.5 \\
 6.5 & 16.0 \\
 9.5 & 14.5 \\
 10.5 & 16.0 \\
 12.5 & 16.0 \\
 14.5 & 21.0 \\
 15.5 & 23.0 \\
\end{array}
\]

When polynomials of successively higher degree are fit to this data, the program calculates the following residual variances:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Residual Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.20688351</td>
</tr>
<tr>
<td>2</td>
<td>7.57981379</td>
</tr>
<tr>
<td>3</td>
<td>1.02062389</td>
</tr>
<tr>
<td>4</td>
<td>0.99174022</td>
</tr>
</tbody>
</table>

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 \( y \)).

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 \( x^0 \), \( C(2) \) is for \( x^1 \), and so forth. The following BASIC code evaluates the polynomial in an obvious—but wrong—way:

\[
Y=C(N+1) \\
\text{FOR } I=N \text{ TO } 1 \text{ STEP } -1 \\
\quad Y=X*Y+C(I+1) \\
\text{NEXT I}
\]

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:

\[
Y=C(1) \\
\text{FOR } I=1 \text{ TO } N \\
\quad Y=X*Y+C(I+1) \\
\text{NEXT I}
\]

Suggestions and Caveats

You could expand the program to plot the data and the fitted polynomials. However, that would make it more machinespecific 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

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This COMPAQ PORTABLE III is so busy in the office, it doesn't get out much.
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.

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 to enhance the ST's scientific and graphics applications. The most convenient connection for both projects would be 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 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
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

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 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 long-word 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 (UDS and LDS respectively). On the cartridge-port connector, you can use UDS in place of address AO, 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 ROM3 or 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 rate.
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rate than the serial, joystick, or MIDI ports and is suitable for many hobbyist projects.

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:

![Circuit Diagram](image-url)
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:

\[
\text{DDD.DDD. } \cdot \text{w.AAAA. where:}
\]

\[
\text{DDD.DDD } = \text{data bits to write}\]
\[
\text{w = read/write control}\]
\[
\text{AAAA = clock register address}\]
\[
\cdot = \text{unused bit}
\]

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 via IC1. If it is a write operation, the D bits stored in IC2 by step 1 are passed to the clock chip. This control pattern is coded as follows:

\[
\text{DDD.DDD. } \cdot \text{w.AAAA. where:}
\]

\[
\text{DDD.DDD } = \text{data bits to write}\]
\[
\text{w = read/write control}\]
\[
\text{AAAA = clock register address}\]
\[
\cdot = \text{unused bit}
\]

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 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-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 2½ 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
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.

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.

Figure 5: The dialogue 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.
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Computer-Aided Design

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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 Pförtmiller’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.

—Dennis Allen, Technical Editor
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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
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—1.4-inch text may be standard on a D-size sheet, but on a B-size sheet it may be 1.6-inch.

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. 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-

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For IBM PCs
Listing 1: The data-structure definitions for the graphics primitives typical in a standard CAD program.

```c
typedef struct /* world coordinate point */
{
    float   x, y;
} wcoord;

typedef struct /* origin, scale, angle ref 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 */
} ooa;

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;
    ooa 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;
    ooa rcs; /* note placement data */
    char *text; /* address of text string */
} note_entity;

typedef struct /* poly entity data */
{
    /* continuation */
}
```

Data Structures

Design and Modeling Transforms

Modelling 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 modelling transformations 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 address 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 displays 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
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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.

The CAD database is organized into three mutually exclusive, circularly linked lists of images. The visible list represents the major category of items. The workstation 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 lists. Images are added, deleted, modified, copied, and transformed using special database-access routines. This data structure is basically the heart of the drafting 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
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-system 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.

BIBLIOGRAPHY


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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 Jiles 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

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

Figure 1: A CAD compiler netlist containing signal names shows the device pins that are to be wired together for a given design.

Figure 2: A list of single pins and the other pins to which they are connected.
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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 3: The CADcompiler main menu.](image)

Figure 4: A CADcompiler completed entry form, showing the currently assigned signal names on the corresponding pins.

![Figure 4: A CADcompiler completed entry form.](image)
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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 interconnected with programmable array logic devices. The program for the two-level MSI commonalities with smaller-scale integrated devices is no longer cost-effective. Modern designs tend to combine register-level MSI 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 design tools. 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 alphabetical 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.

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 systems 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 individual databases.
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.

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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.
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 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.

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 computer-aided 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. 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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COMPUTER-AIDED ROUTING

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

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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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 conductor.

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.

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
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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.

required 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 $\times 2500$), 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...
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.

BIBLIOGRAPHY


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...

True-to-life stories of men and women who didn't do their computer backup and lived to regret it.
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 horror story was
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 action, either. The Cruncher will 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...
The monster
All good monster stories have happy endings where the beast gets his just desserts, and this story is no exception.

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A cartridge is only 5 1/4" tall (its little brother is only 3 1/2") 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.

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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.

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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.

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(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. 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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IGES

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 $x,y,z$ locations 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.

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 twodimensional 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 imple-
mented. 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...
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.
IGES

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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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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

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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.

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 prescribed 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**

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There are virtually as many ways to specify datatypes 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 bit 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 datatypes as there are products available. Some datatypes 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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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.

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
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 (hi) green and the farm road light (fr) red. When a car trips...
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.

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.

---

Figure 5: A Boolean equation and the logic gates a silicon compiler generates for it.

```plaintext
sm Traffic; # Traffic-light controller
!define color red=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, # state defaults to same
state hy tshort - > fg st hl=yellow; # single-bit outputs
state fg | tlong - > fy st fl=green, # default to off, unless
state fy tshort - > hg st fl=yellow; # the designer says to
state defaults to same
# stay in HG when !(car & tlong)
end
```

Figure 6: The state machine description of a traffic-light controller.

Figure 7: The optimized logic diagram for the circuit described in figure 5.
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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.)
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INQUIRY 267
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 $8.7 \times 10^{-11}$. Turbo BASIC 1.0 ran the test in 4.7 seconds with an error of $5.0 \times 10^{-12}$. Table 1 summarizes the results of these and additional tests.

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 $2.4 \times 10^{-16}$. 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

**Table 1: Savage floating-point benchmark results.**

<table>
<thead>
<tr>
<th>Run-time program</th>
<th>Time</th>
<th>Double-precision result</th>
<th>Error</th>
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<tbody>
<tr>
<td>QuickBASIC 2.0</td>
<td>175.5</td>
<td>2499.999999941009d</td>
<td>$5.089 \times 10^{-11}$</td>
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<td>QuickBASIC 3.0</td>
<td>6.4</td>
<td>2500.000000000087</td>
<td>$8.7 \times 10^{-11}$</td>
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<tr>
<td>QuickBASIC 3.0</td>
<td>240.7</td>
<td>2500.000000000024</td>
<td>$2.4 \times 10^{-16}$</td>
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<tr>
<td>QuickBASIC 3.0</td>
<td>175.5</td>
<td>2499.9999999410099</td>
<td>$5.899 \times 10^{-11}$</td>
</tr>
<tr>
<td>Turbo BASIC 1.0</td>
<td>4.7</td>
<td>2500.000000000005</td>
<td>$5.0 \times 10^{-12}$</td>
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<tr>
<td>Turbo BASIC 1.0</td>
<td>139.7</td>
<td>2500.000000000005</td>
<td>$5.0 \times 10^{-13}$</td>
</tr>
</tbody>
</table>
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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 28612 and Wells American's A*Star II. These fast machines are relatively low-cost clones of the IBM PC AT. The 28612 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 28612 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 28612, 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 28612, 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 28612 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 28612

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</tr>
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<td></td>
<td>Austin, TX 78754</td>
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<tr>
<td></td>
<td>(512) 339-6800</td>
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<tr>
<td>Size:</td>
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<td>Components:</td>
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<td>Processor: Intel 80286, switchable between 6 MHz and 12 MHz with one wait state</td>
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<td>Memory: 1 megabyte, expandable to 16 megabytes</td>
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<td></td>
<td>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</td>
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<tr>
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<td>Display: 12-inch monochrome, EGA, or CGA; 80 characters by 25 lines</td>
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<td>Keyboard: 84 keys; 10 function keys; indicator lights for Caps Lock, Scroll Lock, and Num Lock keys</td>
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<tr>
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<td>VO 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</td>
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<tr>
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<td>CGA/EGA color monitor: $529</td>
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<td>360K-byte floppy disk drive: $109</td>
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<td>40-megabyte hard disk drive: $849</td>
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<td>Price:</td>
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<td>With 40-megabyte hard disk drive, 1.2-megabyte 5¼-inch floppy disk drive, and EGA color monitor: $3499</td>
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Wells American A *Star II

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<td>(803) 796-7800</td>
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<tr>
<td></td>
<td>Memory: 1 megabyte, expandable to 16 megabytes</td>
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<td>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</td>
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<tr>
<td></td>
<td>Display: 12-inch monochrome; 80 characters by 25 lines</td>
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<td>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</td>
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<td>VO interfaces: Eight slots; two IBM PC-compatible, six PC AT-compatible, two serial ports; one parallel port; one game port</td>
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<td>12-MHz capability: $395</td>
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<td>Multusier Network Operating System: $395</td>
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<td>A *Star II Network adapter card: $395</td>
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<tr>
<td></td>
<td>A *Star II Network adapter/amplifier card (required for a workstation net with more than 32 stations): $495</td>
</tr>
<tr>
<td>Documentation:</td>
<td>User’s manual, 23 pages</td>
</tr>
<tr>
<td>Price:</td>
<td>Basic Model 300 with 30-megabyte hard disk drive, I/O adapter card, and 1 megabyte of RAM: $2295</td>
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<tr>
<td></td>
<td>Basic Model 300 with A *Star II Network adapter card, monochrome graphics adapter, and monochrome monitor: $2890</td>
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</tbody>
</table>

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 28612

The 28612 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 286\(^\text{12}\) 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 286\(^\text{12}\) (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 286\(^\text{12}\) 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 286\(^\text{12}\) 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 286\(^\text{12}\), 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 286\(^\text{12}\). For the A Star II, you have to run a program called Speed. You enter SPEED and a nu-

---

**DISK ACCESS IN BASIC (IN SECONDS)**

<table>
<thead>
<tr>
<th>WRITE</th>
<th>READ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>7.2</td>
<td>7.2</td>
</tr>
<tr>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>9.5</td>
<td>9.5</td>
</tr>
<tr>
<td>8.8</td>
<td>8.8</td>
</tr>
</tbody>
</table>

**BASIC PERFORMANCE (IN SECONDS)**

<table>
<thead>
<tr>
<th>SIEVE CALCULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>

**SYSTEM UTILITIES (IN SECONDS)**

<table>
<thead>
<tr>
<th>40K FORMAT/DISK COPY</th>
<th>40K FILE COPY</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**SPREADSHEET (IN SECONDS)**

<table>
<thead>
<tr>
<th>LOAD</th>
<th>RECALCULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>15.6</td>
</tr>
<tr>
<td>9.2</td>
<td>8.5</td>
</tr>
<tr>
<td>2.8</td>
<td>5.0</td>
</tr>
</tbody>
</table>

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 286\(^\text{12}\) 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 BASICA 3.2 were used for the 8-MHz IBM PC AT.

---

**SYSTEM REVIEW**

The 286\(^\text{12}\) 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 286\(^\text{12}\)

The 286\(^\text{12}\) 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.

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meric value for the proper speed (e.g., \texttt{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\textsuperscript{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\textsuperscript{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 S1Ps (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 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\textsuperscript{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 only 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\textsuperscript{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 Fl key and proceed to the setup menu in ROM. As with the 28612, 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 28612 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 28612 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 28610, 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 28612, 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.

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ance prepaid, to the MicroServe repair facility.

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Inquiry 186 for End-Users. Inquiry 187 for DEALERS ONLY.
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 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 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...
HARDWARE REVIEWS

Turbo-Amiga

<table>
<thead>
<tr>
<th><strong>Type</strong></th>
<th>Expansion chassis with a 68020 processor, a 68881 math coprocessor, and 512K bytes of RAM for the Commodore Amiga 1000</th>
</tr>
</thead>
</table>
| **Company** | Computer System Associates Inc.  
7564 Trade St.  
San Diego, CA 92121  
(619) 566-3911 |
| **Size** | 10 by 9 by 8 1/4 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 31/2-inch disk with ABaSIIC 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 DEFNSG statement was removed) before it would run. Tests were run using Kickstart/Workbench 1.2. The spreadsheet used was Lattice’s Unilcic 1.0; Metacomco’s ABasiIC 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 CSAMecon 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 CSAMecon 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_Tank 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 co-processor. 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 (777.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.

<table>
<thead>
<tr>
<th></th>
<th>FORTRAN</th>
<th>Modula-2</th>
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<tr>
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<td>5.9</td>
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<td>Turbo-Amiga</td>
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<td>1.4</td>
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<td>Long Sieve</td>
<td></td>
<td></td>
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<td>Amiga 1000</td>
<td>6.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Turbo-Amiga</td>
<td>1.2</td>
<td>1.7</td>
</tr>
</tbody>
</table>
HARDWARE REVIEWS

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 cabled 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
The new Professional Image Board is a PC board which allows an ordinary home video camera (color or black-and-white) to be plugged into an IBM personal computer or IBM compatible. Now, live, fast action scenes can be instantly captured in full color and frozen. The frozen pictures can be computer enhanced feature by feature and stored on a floppy or hard disk. The frozen pictures can also be transmitted to any remote computer in the world via modem.

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- Mixing external image with internal image in live mode
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(714) 839-3724
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.

<table>
<thead>
<tr>
<th>Company</th>
<th>Name</th>
<th>Price</th>
<th>Type</th>
<th>Buttons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft Corp.</td>
<td>Microsoft Mouse:</td>
<td>$175</td>
<td>Mechanical</td>
<td>2</td>
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<tr>
<td>16011 Northeast 36th Way</td>
<td>Bus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO Box 9707</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redmond, WA 98073</td>
<td>Serial</td>
<td>$195</td>
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<tr>
<td>(206) 882-8080</td>
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<tr>
<td>Logitech Inc.</td>
<td>Logitech Bus Mouse</td>
<td>$149</td>
<td>Optomechanical</td>
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<tr>
<td>805 Veterans Blvd</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Redwood City, CA 94063</td>
<td>C7 Mouse</td>
<td>$99</td>
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<td>3</td>
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<tr>
<td>(415) 365-9952</td>
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<td>Mouse Systems Corp.</td>
<td>PC Mouse Bus Plus</td>
<td>$199</td>
<td>Optical</td>
<td>3</td>
</tr>
<tr>
<td>2600 San Thomas Expressway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Clara, CA 95051</td>
<td>SummaMouse</td>
<td>$119</td>
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<tr>
<td>(408) 988-0211</td>
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<tr>
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<td></td>
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<tr>
<td>777 State Street Ext.</td>
<td></td>
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<tr>
<td>Fairfield, CT 06430</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(203) 384-1444</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Torrington Co.</td>
<td>Manager Mouse:</td>
<td>$229</td>
<td>Mechanical</td>
<td>3</td>
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<tr>
<td>59 Field St.</td>
<td>1001C-IR</td>
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<td></td>
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<tr>
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<td></td>
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<td>1001C-KF</td>
<td>$179</td>
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<tr>
<td>(203) 482-9511</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

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 Mouse
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
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

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**HARDWARE REVIEWS**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Power</th>
<th>Connector</th>
<th>Cord length</th>
<th>Pad size</th>
<th>Resolution</th>
<th>Systems</th>
<th>Additional bundled software</th>
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</thead>
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<td>Internal</td>
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<td>100</td>
<td>IBM PC, XT, AT, Compact, and compatibles</td>
<td>Keyfree, TelePaint</td>
</tr>
</tbody>
</table>

**continued**
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HARDWARE REVIEWS

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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Four C Language Interpreters

John Unger

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 nonextendible 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 revised with new programs

John Unger (P.O. Box 95, Hamilton, VA 22068) is a geophysicist for the U.S. government who uses the C language to write software for earthquake research.
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, COMPIL, 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 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 breakpoint() 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 software.

<table>
<thead>
<tr>
<th>RUN/C version 2.03</th>
<th>C-terp version 2.22</th>
<th>Instant-C version 2.20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>C language interpreters</td>
<td>C language interpreter</td>
</tr>
<tr>
<td><strong>Company</strong></td>
<td>Lifeboat Associates</td>
<td>Gimpel Software</td>
</tr>
<tr>
<td></td>
<td>55 South Broadway</td>
<td>3207 Hogarth Lane</td>
</tr>
<tr>
<td></td>
<td>Tarrytown, NY 10591</td>
<td>Collegeville, PA 19426</td>
</tr>
<tr>
<td></td>
<td>(914) 332-1875</td>
<td>(215) 584-4261</td>
</tr>
<tr>
<td><strong>Format</strong></td>
<td>Two 5 1/4-inch floppy disks</td>
<td>Two 5 1/4-inch floppy disks</td>
</tr>
<tr>
<td><strong>Computer</strong></td>
<td>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</td>
<td>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</td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
<td>530-page user’s manual</td>
<td>148-page user’s manual</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>Run/C: $120</td>
<td>$298</td>
</tr>
<tr>
<td></td>
<td>Run/C Professional: $250</td>
<td></td>
</tr>
</tbody>
</table>

SOFTWARE REVIEWS
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 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 Microsoft 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 forh 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.

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.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>C-terp 2.20</th>
<th>Instant-C 2.20</th>
<th>Microsoft C 4.0</th>
<th>Run/C 2.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve</td>
<td>40</td>
<td>59:37</td>
<td>59:37</td>
<td>5:29:33</td>
</tr>
<tr>
<td>Float</td>
<td>40:09</td>
<td>16:29</td>
<td>16:29</td>
<td>51:58</td>
</tr>
<tr>
<td>Fileio</td>
<td>10:49</td>
<td>23:10</td>
<td>23:10</td>
<td>1:21:58</td>
</tr>
</tbody>
</table>

continued
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.

<table>
<thead>
<tr>
<th>Error code</th>
<th>Type of error</th>
<th>Location in listing 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>misspelled variable name</td>
<td>for loop for fahr—line 11</td>
</tr>
<tr>
<td>S2</td>
<td>missing ;</td>
<td>end of line 11</td>
</tr>
<tr>
<td>S3</td>
<td>missing { and }</td>
<td>lines 10 and 13</td>
</tr>
<tr>
<td>L1</td>
<td>integer instead of floating-point division</td>
<td>line 11</td>
</tr>
<tr>
<td>L2</td>
<td>integer instead of floating-point format</td>
<td>line 12</td>
</tr>
</tbody>
</table>

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.

```c
#define UPPER 300.0 /* upper limit of Fahrenheit degrees*/
#define LOWER 0.0  /* lower limit of Fahrenheit degrees*/
#define STEP 20.0  /* step to increment Fahr. degrees*/

main()
{
    float fahr, celsius;
    printf("\t\t%4.0f\t\t%6.1f\n", fahr, celsius);
    for (fahr = LOWER; fahr <= UPPER; fahr += STEP, fahr = UPPER)
    {
        celsius = (5.0/9.0) * (fahr-32.0);
        printf("\t\n\t%6.1f\n", fahr, celsius);
    }
}
```

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 the 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/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 unidentified 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 missing closing brace { } 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

continued

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 'fahr' and the cursor was placed at the first character in fahr. 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 'if' for a missing left brace and Missing closing brace { }; possible un-terminated 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.
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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.

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, Language 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 consist 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 to the window procedure with SendMessage. SendMessage 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

### Table 1: The major components of the Windows Software Development Kit.

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<th>Executable windowing support</th>
<th>Sample C programs</th>
<th>Sample Pascal program</th>
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<tr>
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### Figure 1: The architecture of Windows as seen from an application.
SOFTWARE REVIEWS

Task entry point Synchronous
Win Main I event

Initialize application data
Register the application’s window class
Create and display a window
Post Message
Message loop
Get Message
Application queue
Translate virtual keystroke messages into character messages
DispatchMessage
Send Message

Exit task
Yes
WM-Quit
No
TranslateMessage

switch (message)
case WM_SYSCOMMAND
A typical response to the user selecting “About” from the system menu is putting up a dialog that describes the application you have written. Otherwise take the default for this message.
case WM_
Other messages for which you want a special action to occur.
case WM_DESTROY
PostQuitMessage (a typical response) posts a WM_QUIT message to the application queue and returns immediately.
default
All messages not handled by applications are handed to the default window procedure DefWindowProc.

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.

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 use Dialog to 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 the X() pseudographics 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 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.

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Type
Libraries and utilities for making stand-alone Windows applications

Company
Microsoft Corp.
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Format
Seven 5¼-inch MS-DOS disks

Computer
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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 menus 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 Message-Box 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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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.

**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.

David Hart (855 High St., Chestertown, MD 21620) is an independent software developer and freelance writer. Lee Hart (201 Cedar St., Chestertown, MD 21620) works in the Naval Architecture Department at Advanced Marine Enterprises and regularly consults with MicroSystem Specialists in Blacksburg, Virginia.

---

**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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**Format**
Three 51/4-inch floppy disks

**Computer**
IBM PC, XT, AT, or compatible with 512K bytes of memory, two floppy disk drives or a hard disk, and a graphics adapter; mouse recommended

**Necessary Software**
DOS 2.0 or higher

**Language**
Smalltalk/V, Assembly language

**Options**
EGA/VGA color-extension kit: $49.95
Communications package: $49.95
Goodies extension kit: $49.95

**Documentation**
514-page Tutorial and Programming Handbook; tutorial source code on disk; Prolog/V documentation on disk

**Price**
$99.95

**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 BITnet. 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.

Mat Davis (Virginia Polytechnic Institute, Department of Computer Science, 562 McBryde Hall, Blacksburg, VA 24061) is an instructor of computer science.
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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 KAIN T.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)
```

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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:

```
(DefContext 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 QAcoint 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

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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-
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<th>Acquaint 2.4F</th>
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<td>Frame-based knowledge-development system and expert-system tool</td>
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<tr>
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<td>Lithp Systems BV</td>
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<tr>
<td><strong>Format</strong></td>
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<tr>
<td>Two 5¼-inch floppy disks</td>
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<td><strong>Computer</strong></td>
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<tr>
<td>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</td>
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<tr>
<td><strong>Language</strong></td>
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<td>Acquaint User's Manual</td>
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<tr>
<td><strong>Price</strong></td>
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<td>$4000</td>
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Acquaint has an interface to muLISP that lets you use the language’s standard functions and call them from within rules. For example, DefConcept RES-MAN 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. For example, let’s say that BAND9 is a variable that contains the number of departments. In Acquaint, you can enter in a question such as DefConcept Concept 10 Department List (BAND9) = Department List (BAND9 - 1), which tells you the number of departments left to ask.

You may 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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Peter Norton

COMPUTING

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.

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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 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 zeros.

The speed of Zoomracks in the benchmark 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

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APPLICATION REVIEWS

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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Puttering with Yin and Yang

Jerry Pournelle

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 PC-compatible.

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 PC-compatible.

I took Zebediah down to the AAAS newsroom to log on to BIX and send some items into Microbytes. Zebediah 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 PC-compatible 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

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.

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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 filter 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 oversized and thus easy to find. The MultiSpeed, for no sane reason, has a narrowed Return key and an oversized ] ] 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 PCXFFER 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 PCXFFER. 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 every 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.
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 floppy.

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 surely 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.

**continued**

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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 impossible 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...
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nd they work. The links so fast you'd think 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 CHAOS MANOR, 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, Robbie 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 on 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.

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* All but Norton SI are the PC magazine Labs public domain benchmark tests.

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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.

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.

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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.

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 and 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 tightly 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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Inquiry 63
Processor Wars

Bruce Webster

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 IIOS 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 display 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 support 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 a 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 sitting 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

Bruce Webster, a consulting editor for BYTE, can be reached c/o BYTE, P.O. Box 1910, Orem, UT 84057, or on BIX as bwebster.
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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 desk­
top computer? Yes. I have a friend, Jay Ekstrom, who special­
izes 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

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 upset 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 dis­
plays 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 de­
v eloping software for it: running a text screen off an 80­column
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, tinkers, 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
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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 benchmark results.

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 30 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.)

<table>
<thead>
<tr>
<th>Test</th>
<th>Access 386 System</th>
<th>Compaq Portable</th>
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</thead>
<tbody>
<tr>
<td>time</td>
<td>compile run time</td>
<td>compile run time</td>
</tr>
<tr>
<td>Sieve</td>
<td>0.8 7.8</td>
<td>4.3 70.2</td>
</tr>
<tr>
<td>Sort</td>
<td>0.9 16.2</td>
<td>5.0 117.9</td>
</tr>
<tr>
<td>IMAT</td>
<td>0.9 3.5</td>
<td>4.4 38.2</td>
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<tr>
<td>RMAT</td>
<td>1.0 9.7</td>
<td>4.9 86.5</td>
</tr>
<tr>
<td>Reals</td>
<td>0.8 9.4</td>
<td>3.9 67.6</td>
</tr>
</tbody>
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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; 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 choose.

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
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**MODEM**

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>1200</th>
<th>1200H</th>
<th>1200C</th>
<th>9600C</th>
<th>2400</th>
<th>2400D</th>
<th>2400C</th>
<th>2400BC</th>
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<tbody>
<tr>
<td>Auto-dial, auto-answer</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Auto-speed selection</td>
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<td>*</td>
<td>*</td>
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<tr>
<td>Call progress detection</td>
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<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Adaptive dialing</td>
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<td>*</td>
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<tr>
<td>Latest Hayes AT command set</td>
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<td>2 year warranty</td>
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<td>User friendly 'help' menu</td>
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<tr>
<td>CCITT V.23</td>
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<tr>
<td>CCITT V.22 bis</td>
<td>*</td>
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<td>*</td>
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<tr>
<td>CCITT V.22</td>
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<tr>
<td>Bell 103/212A</td>
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<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Automatic selection between Bell and CCITT</td>
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<td>*</td>
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<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Automatic data/voice switching</td>
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<tr>
<td>Manual data/voice switching</td>
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<td>*</td>
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<tr>
<td>Synchronous operation</td>
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<td>*</td>
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<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>Auto fail back</td>
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<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<tr>
<td>2 sets of 32 digits stored phone number</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

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ACCRO TO WEBSTER

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 \( (1, 4, 9, \ldots, 10,000) \).

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:

\[
function GCD(I: Integer) : Integer;
end; \{ of func GCD \}
\]

Listing 1: A source code fragment in Professional Pascal, showing its ability to declare variables local to a begin...end block.

```pascal
for Index := 1 to 100 do declare
var
  ISqr : Integer;
begin
  ISqr := I*I;
  Writeln,['1:n',',ISqr10];
end;
```

continued
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ACCORDING TO WEBSTER

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 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.

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;
{ 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*V1 + V2*V2;
end;
{ of func +* }
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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 damn 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? Meta Ware 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.

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.

<table>
<thead>
<tr>
<th>Test</th>
<th>Turbo Pascal</th>
<th>Professional Pascal</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>compile:</td>
<td>compile/link:</td>
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<tr>
<td>Sieve</td>
<td>0.8 secs</td>
<td>26.4 secs</td>
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<tr>
<td></td>
<td>code: 368 bytes</td>
<td>code: 304 bytes</td>
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<tr>
<td></td>
<td>data: 8240 bytes</td>
<td>data: 8253 bytes</td>
</tr>
<tr>
<td></td>
<td>.COM: 11,753 bytes</td>
<td>.EXE: 25,682 bytes</td>
</tr>
<tr>
<td></td>
<td>run: 7.8 secs</td>
<td>run: 4.0 secs</td>
</tr>
<tr>
<td>Sort</td>
<td>compile:</td>
<td>compile/link:</td>
</tr>
<tr>
<td></td>
<td>0.9 secs</td>
<td>27.0 secs</td>
</tr>
<tr>
<td></td>
<td>code: 816 bytes</td>
<td>code: 550 bytes</td>
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<tr>
<td></td>
<td>data: 208 bytes</td>
<td>data: 415 bytes</td>
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<tr>
<td></td>
<td>.COM: 12,200 bytes</td>
<td>.EXE: 19,942 bytes</td>
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<tr>
<td></td>
<td>run: 16.2 secs</td>
<td>run: 5.1 secs</td>
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<tr>
<td>IMAT</td>
<td>compile:</td>
<td>compile/link:</td>
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<tr>
<td></td>
<td>0.9 secs</td>
<td>33.9 secs</td>
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<tr>
<td></td>
<td>code: 848 bytes</td>
<td>code: 568 bytes</td>
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<tr>
<td></td>
<td>data: 15,040 bytes</td>
<td>data: 15,054 bytes</td>
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<tr>
<td></td>
<td>.COM: 12,239 bytes</td>
<td>.EXE: 42,844 bytes</td>
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<td></td>
<td>run: 3.5 secs</td>
<td>run: 2.8 secs</td>
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<td>RMAT</td>
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<td>compile/link:</td>
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<tr>
<td></td>
<td>1.0 secs</td>
<td>33.9 secs</td>
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<td></td>
<td>code: 896 bytes</td>
<td>code: 630 bytes</td>
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<tr>
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<td>run: 23.0 secs</td>
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<tr>
<td>Reals</td>
<td>compile:</td>
<td>compile/link:</td>
</tr>
<tr>
<td></td>
<td>0.8 secs</td>
<td>28.4 secs</td>
</tr>
<tr>
<td></td>
<td>code: 304 bytes</td>
<td>code: 312 bytes</td>
</tr>
<tr>
<td></td>
<td>data: 80 bytes</td>
<td>data: 69 bytes</td>
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<tr>
<td></td>
<td>.COM: 11,694 bytes</td>
<td>.EXE: 26,496 bytes</td>
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<tr>
<td></td>
<td>run: 9.4 secs</td>
<td>run: 2.8 secs</td>
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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...
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 important to you; 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

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For more information, contact Dr. Paul Rapoport, Dept. of Music, McMaster University, 1280 Main Street W, Hamilton, Ontario, Canada L8S 4M2.

### 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 MOS-FET above the source drain, and I'll see you on the bit stream.

Thanks to Frank Boosman and Eric Zacher 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

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 microcomputers 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 one character repeats continually. For example:

Let's use two programs for compressing ASCII text data, which typically contains only the 128 possible double-octet or repeated spaces.

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., doubled] 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. 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.

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 piel: 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 an 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.

```pascal
procedure Compress;
const escapechar = $F800;
screenseg = $8800;
scrensize = 4000;
var OutputFile: Text;
OutputFileName: string[ 80];
runlength, currentword, nextword, scrnofs, items: integer;
begin
  OutputFileName := paramSTR(l);
  Assign(OutputFile, OutputFileName);
  Rewrite(OutputFile);
  write(OutputFile, '(');
  items := 0;
  scrnofs := 0;
  currentword := MemW(screenseg: scrnofs); (read word from screen memory)
  scrnofs := scrnofs + 2;
  repeat
    runlength := 0;
    repeat
      nextword := MemW(screenseg: scrnofs);
      scrnofs := scrnofs + 2;
      runlength := runlength + 1;
    until (nextword <> currentword) or (scrnofs > scrensize);
    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 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 > scrensize;
  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 COMRESS.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

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array, found by the $\text{Ofs( )}$ function, and the size of the array as parameters; indexing must be done at a low level with $\text{MemW( )}$. You can expand a screen with a simple call to this procedure, for example, $\text{expand( ofs(pi cl), 367);}$.

**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 separate 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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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.

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 runtime 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

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, regrettably, cannot respond to each inquiry.

JUNE 1987 • BYTE 321
If constructing an expert system from scratch strikes you as too much work, VP-Expert has a shortcut method of creating a rule base.

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.

If constructing an expert system from scratch strikes you as too much work, VP-Expert has a shortcut method of creating a rule base.
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

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JUNE 1987 • BYTE 323
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 tips 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 program. 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 MSDOS 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 FedEx 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 prep's the machine for powering down (closes files, etc.). Activating Shutdown blanks 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 800X 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.


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
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 are committed to the Plus remaining as an entry-level Macintosh.

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 68K/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 beige. I think that says something about long-term plans.

MORE REACTIONS FROM THE REVIEWER

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 - ummm - 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.

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 Kozlak 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 Leob 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 ripherhuberet \ (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 leob, Tue Mar 10 09:07:53 1987. A comment to message 36.

No, they are leaving that niche for the third-party people like Levo. They are going to have enough headaches (Apple, that is) just supporting the II.


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.

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Inquiry 184
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.


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 all (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 than 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 comps 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.


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 #45, from reviews6, Thu Mar 12 01:48:45 1987. A comment to message 45.

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 #47, from tom_thompson, Thu Mar 12 08:30:31 1987. A comment to message 45.

Also, a number of hardware components, such as the Integrated Voz Machine and the video display, use the 6-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.


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).
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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.

A comment to message 38.

There is no good reason why a 68020 machine should cost that much more than a 68000, 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.

A comment to message 39.

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 TMS34010, upon which the II's transfer nodes 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

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?

I believe that is with 1-megabyte chips.

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 II COLOR CAPABILITIES

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?

The Macintosh II Video Card Expansion Kit, as listed, expands the standard display to support 256 colors instead of 16 colors.

The video-card documentation never mentioned blitting.

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 TMS34010, upon which the II's transfer nodes are based—and has stated in materials sent to developers that they themselves were working on such a product.

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4-Mbit chips --- 4Mx8/8Mb where: memory bank 1/memory bank 2
4-Mbit chips --- 16Mb/32Mb
16-Mbit chips --- 64Mb/128Mb
1-Mbit chips --- 4Mb/8Mb

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.


Interesting. Sun's 3-Series workstations get away with one wait state, I think. Also any Mac Plus seems to have 120-nsec chips in it. Nice to know they aren't needed...


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?


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 the 68020 is booking, doesn't it?


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-MiB 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 skraeglof (Stefan Kraeglof), Tue Mar 10 17:52:05 1987. A comment to message 24.

Actually it's 115 nsec from vax 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 /AS. 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 pretty much 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-MiB 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.


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 80386-based machines? Also 100-nsec RAMs. Why Compaq uses the same speed RAMs in their 16-MiB 80386 machines as their 12-MiB 80286 machines beats me. But with their replacement of their 8-MiB 80286 machine line with 12-MiB 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)?


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 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 tikes (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...
Those fantastic Byte covers—and boy, do they look great on this stylish, ¥4 sleeve T-shirt from Robert Tinney Graphics! The colored sleeves and neckline vividly complement the full-color design. And don't mistake this for a rubbery patch that cracks and peels off after a few washings. This is true four-color process: the permanent inks are silk-screened into the fabric, resulting in a beautiful, full-color image that lasts!

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for copy protection. However, you can always use the same
copy-protection scheme as usual on your floppy, and use it as a
key disk (like Habawri ter).

### 1040 MEMORY UPGRADE

atari.st/main #1918, from jimomura (Jim Omura), Tue Mar 17

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

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,

atari.st/main #1922, from jim_kent (Jim Kent), Wed Mar 18

Do you have to do any software fixes for the 1040 to recognize
the 4 megs?

A comment to message 212.

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

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 212.

Yeah, 411K 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 make a daughterboard to hold the new chips. Other
than that, it should just be a matter of bringing the extra
address line and the unused (used) 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 helps
the user about a "crashing CloseWindow" problem. We finish up with some
thoughts on task priorities under AmigaDOS.

### TIMER GRANULARITY

amiga/softw.devlpmt #3904, from tjjeffries (Tom Jeffries), Sat
Mar 7 02:03:34 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 I was thinking about something different.

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
g et 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 charlie (Charlie Heath), Sat

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, I would have expected the blitter to make

amiga/softw.devlpmt #3907, from tjjeffries, 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? Hmm. . . 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 VB blank
interrupt handler - they're pretty easy to install with RKM
documentation.

amiga/softw.devlpmt #3911, from tjjeffries, Sat Mar 7 17:30:32

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
tings even faster.

continued
The "first-to-nineteenth-floor" $158,300 disk drive decision.

Today, in the office elevator, Dave Dodge, Electronics Engineer, and Pete Doyle, Information Systems Specialist, will firm up their disk drive selection for a major microcomputer purchase that they are making for their company. The buying decision is theirs because they are "Power Users" of computers at work and at home.

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BYTE means business.
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 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!

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.

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 someone here has figured it out. Thanks.

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?

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 someone here has figured it out. Thanks.

Each 8520 has a "time of day" binary counter. One runs off a nominal 60-Hz tick signal, the other runs off the 154-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...

CRASHER CLOSEWINDOW

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 40 gadgets in it. I do play with the gadget list a bit, but everything is stable when I go 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 to get confused. A couple of people have crashed disks with the Hanoi program and the 2.05n version of Matt's shell.

Back to the window problem, when it crashes the Guru is an 810... . In my code, backtrace to the CloseWindow( ) call, which claims the free list is corrupt. Since I have a version of Snopp built into my program, I know that it isn'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 the last bug and it is making me crazy!

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.

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.

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

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.

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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 their demands are typically less.

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<td>IBM 15.160 cps, 15n Wide Carriage</td>
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<table>
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<tr>
<th>UPGRAGE OPTIONS</th>
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<tr>
<td>Hercules® compatible monochrome graphic card w/printer port</td>
</tr>
<tr>
<td>Monochrome monitor</td>
</tr>
<tr>
<td>2MB hard disk drive kit</td>
</tr>
<tr>
<td>360K floppy drive</td>
</tr>
<tr>
<td>XT serial/parallel/backplane port for PC XT only</td>
</tr>
<tr>
<td>6087-1 (8 mhz)</td>
</tr>
<tr>
<td>6087-2 (16 mhz)</td>
</tr>
<tr>
<td>6087-10</td>
</tr>
<tr>
<td>30MB hard disk drive only</td>
</tr>
<tr>
<td>30MB hard disk drive only</td>
</tr>
<tr>
<td>Enhanced keyboard</td>
</tr>
</tbody>
</table>

**PACT-286-8** (8 mhz Zero Wait State)

- IBM AT Compatible
- 6/8 mhz 0 Wait State, Norton S/9.2
- 512K Installed, Expandable to 1 MB
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- Floppy and Hard Disk Drives Controller
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- Clock/Calendar with Battery Back Up
- Optional Math Co-Processor 80287-8
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- One Year Warranty

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- On Board Memory
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- Floppy/Hard Disk Drive Controller
- Maxi-Switch AT Keyboard
- 230 W (max.) UL/CSA Listed Power Supply
- DOS 3.2, GW Basic
- One Year Warranty

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<tr>
<th>Model</th>
<th>50 Meg</th>
<th>75 Meg</th>
<th>100 Meg</th>
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1 Yr Warranty

**ATASI**

40MEG HARDDRIVE

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<th>3046</th>
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<td>Qty 1</td>
<td>479.00</td>
<td>459.00</td>
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**MEAD**

PRODUCTS

MONITORS

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<tr>
<th>Model</th>
<th>12&quot; TTL Amber Hires 720x360</th>
<th>14&quot; RGB Color Med res 640x400</th>
<th>13&quot; EGA 640x350</th>
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**Epson**

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<th>Fx86E</th>
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<th>LQ800</th>
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**MINISCRIBE**

HARDDISK

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**MICRONEX**

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**AMOEBA**

MONITORS

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**MEMORY CHIPS**

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<th>Model</th>
<th>15ONS Set of 9</th>
<th>256K 15ONS Set of 9</th>
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<tr>
<td>Qty 5</td>
<td>159.00</td>
<td>260.00</td>
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<td>WD8704-2 Auto</td>
<td>1.95</td>
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<td>WD8704-2 Auto</td>
<td>0.95</td>
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### Miscellaneous Chips

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>WD7576 Lookout</td>
<td>24.95</td>
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<tr>
<td>WD8704 Rumble</td>
<td>6.95</td>
<td></td>
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<tr>
<td>WD8704 Ecom Echo</td>
<td>2.95</td>
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<td>WD8704 Stand Down</td>
<td>5.95</td>
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<td>WD8704 Corn</td>
<td>2.75</td>
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<tr>
<td>WD8704 Tilt</td>
<td>9.95</td>
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<tr>
<td>WD8704 Clarify</td>
<td>17.45</td>
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<tr>
<td>WD8704 Echo</td>
<td>15.95</td>
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<tr>
<td>WD8704-2 Auto</td>
<td>11.95</td>
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### Dynamic RAMs

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<tr>
<th>Part No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>TS4105-5</td>
<td>128K x 1</td>
<td>(1500)</td>
</tr>
<tr>
<td>TS4105-10</td>
<td>256K x 1</td>
<td>(2500)</td>
</tr>
<tr>
<td>TS4105-20</td>
<td>512K x 1</td>
<td>(5000)</td>
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### Mainframe RAMs

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<tr>
<th>Part No.</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>TS4105-5</td>
<td>128K x 1</td>
<td>(1500)</td>
</tr>
<tr>
<td>TS4105-10</td>
<td>256K x 1</td>
<td>(2500)</td>
</tr>
<tr>
<td>TS4105-20</td>
<td>512K x 1</td>
<td>(5000)</td>
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### CD-CMOS

<table>
<thead>
<tr>
<th>Part No.</th>
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</thead>
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<tr>
<td>CD4001</td>
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<tr>
<td>CD4002</td>
<td>4.99</td>
<td></td>
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<tr>
<td>CD4003</td>
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<tr>
<td>CD4004</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4005</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4006</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4007</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4008</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4009</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4010</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4011</td>
<td>4.99</td>
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<td>4.99</td>
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</tr>
<tr>
<td>CD4014</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4015</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4016</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>CD4017</td>
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<tr>
<td>CD4018</td>
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<tr>
<td>CD4020</td>
<td>4.99</td>
<td></td>
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<tr>
<td>CD4021</td>
<td>4.99</td>
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### IC Sockets

<table>
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<th>Part No.</th>
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<tr>
<td>IC4001</td>
<td>Low Profile</td>
<td>0.95</td>
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<td>IC4002</td>
<td>Low Profile</td>
<td>0.95</td>
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<tr>
<td>IC4003</td>
<td>Low Profile</td>
<td>0.95</td>
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<tr>
<td>IC4004</td>
<td>Low Profile</td>
<td>0.95</td>
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<tr>
<td>IC4005</td>
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<tr>
<td>IC4006</td>
<td>Low Profile</td>
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</tr>
<tr>
<td>IC4007</td>
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<tr>
<td>IC4008</td>
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<tr>
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<td>0.95</td>
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<tr>
<td>IC4010</td>
<td>Low Profile</td>
<td>0.95</td>
</tr>
<tr>
<td>IC4011</td>
<td>Low Profile</td>
<td>0.95</td>
</tr>
<tr>
<td>IC4012</td>
<td>Low Profile</td>
<td>0.95</td>
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<tr>
<td>IC4013</td>
<td>Low Profile</td>
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<td>IC4014</td>
<td>Low Profile</td>
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<td>IC4015</td>
<td>Low Profile</td>
<td>0.95</td>
</tr>
<tr>
<td>IC4016</td>
<td>Low Profile</td>
<td>0.95</td>
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### Satellite TV D/A Decoder Board

<table>
<thead>
<tr>
<th>Part No.</th>
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</thead>
<tbody>
<tr>
<td>MM5321N</td>
<td>$11.95</td>
<td></td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Item</th>
<th>Price</th>
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<tr>
<td>LIST PRICE</td>
<td>$199</td>
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<td>4 waterbase pens</td>
<td>$15</td>
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<tr>
<td>4 oil base pens</td>
<td>$15</td>
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<td>100 sheets coated paper</td>
<td>$5</td>
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<td>10 sheets overhead</td>
<td>$5</td>
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<td>transparency film</td>
<td>$6</td>
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<tr>
<td>Top rated business graphics software</td>
<td>$29</td>
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<tr>
<td>package for PC</td>
<td></td>
</tr>
<tr>
<td>Parallel PC cable</td>
<td>$19</td>
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## Static RAMs

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
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<tbody>
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<td>5101</td>
<td>256x4 (45V)</td>
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<td>2111-4</td>
<td>1024x4 (45V)</td>
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A new family of high speed CMOS logic featuring the speed of low power CMOS without the long propagation delay, combined with the advantages of high voltage levels, high noise immunity, and improved output drive.

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- 74HC00
- 74HC04
- 74HC08
- 74HC10
- 74HC20
- 74HC24
- 74HC30
- 74HC31
- 74HC33
- 74HC35
- 74HC38
- 74HC40
- 74HC43
- 74HC47

### 74HC100

- 74HC100
- 74HC101
- 74HC103
- 74HC105
- 74HC106
- 74HC107
- 74HC108
- 74HC109
- 74HC110
- 74HC111
- 74HC112
- 74HC113

### 74HC4000

- 74HC4000
- 74HC4004
- 74HC4008
- 74HC4010
- 74HC4020
- 74HC4030
- 74HC4044

### 74HC1000

- 74HC1000
- 74HC1010
- 74HC1030
- 74HC1050
- 74HC1060
- 74HC1070
- 74HC1080
- 74HC1090
- 74HC1100
- 74HC1110
- 74HC1120

### 74HC10000

- 74HC10000
- 74HC10100
- 74HC10300
- 74HC10500
- 74HC10600
- 74HC10700
- 74HC10800
- 74HC10900
- 74HC11000

### 74HC40000

- 74HC40000
- 74HC40040
- 74HC40080
- 74HC40100
- 74HC40200
- 74HC40300
- 74HC40440

### 74HC100000

- 74HC100000
- 74HC101000
- 74HC103000
- 74HC105000
- 74HC106000
- 74HC107000
- 74HC108000
- 74HC109000
- 74HC110000
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  1200 BAUD HALF CARD
- EASYOATA-128 $119.95
  1200 BAUD FULL CARD
- EASYOATA-240 $219.95
  2400 BAUD HALF CARD
- EASYOATA-248 $199.95
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  RETURN KEYS
- 82 KEY TYPEWRITER LAYOUT

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  THE SAME SYSTEM

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  GRAPHICS CARD IN THE SAME SYSTEM

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  - PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS
  - AND DOES NOT INCLUDE A PARALLEL PORT

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- GAME PORT
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- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
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2nd SERIAL PORT

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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 the 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.

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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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