BYTE

THE SMALL SYSTEMS JOURNAL®

AUGUST 1987 VOL.12, NO.9

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Prolog

bo C: **NEW!**

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Sieve benchmark

	Turbo C	Microsoft® C
Compile time	*2.4*	13.51
Compile and link time	*4.1*	18.13
Execution time	*3.95*	5.93
Object code size	*239*	249
Execution size	*5748*	7136
Price	*$99.95*	$450.00

Benchmark run on an IBM PS/2 Model 60 using Turbo C version 1.0 and the Turbo Linker version 1.0, Microsoft C version 4.0 and the MS overlay linker version 3.51.

Technical Specifications

- ☑ Compiler: One-pass optimizing compiler generating linkable object modules. Included is Borland's high-performance Turbo Linker.™ The object module is compatible with the PC-DOS linker. Supports tiny, small, compact, medium, large, and huge memory model libraries. Can mix models with near and far pointers. Includes floating point emulator (utilizes 8087/80287 if installed).
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- ☑ Register variables.
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- ☑ License to the source code for Run-time Library available.

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Minimum system requirements: All products run on IBM PC, XT, AT, PS/2, portable and true compatibles. PC-DOS (MS-DOS) 2.0 or later. 384K RAM minimum. Basic Telecom and Editor Toolboxes require 640K.

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Michael Abrash, Programmer's Journal

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Garry Ray, PC Week "

BI-1131

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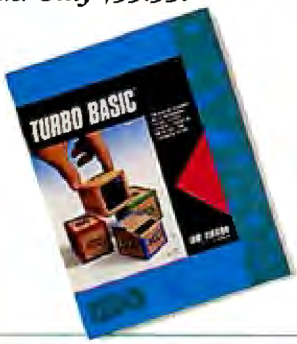

A technical look at Turbo Basic

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- ☑ Floating-point support, with full 8087 (math co-processor) integration. Software emulation if no 8087 present
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Source code included.
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- Tab, insert, overstrike modes, line center etc.

Includes source code.
Only $99.95!

BI-1131

BYTE

AUGUST 1987
VOLUME 12
NUMBER 9

Features/99

Contents

Cover painting by Robert Tinney

Themes/145

Reviews/197

Kernel/241

KERNEL

LISTINGS

DEPARTMENTS

BEST OF BIX

BYTE (ISSN 0360-5280) is published monthly with additional issues in June and October by McGraw-Hill Inc. Founder: James H. McGraw (1860-1948). Executive, editorial, circulation, and advertising offices: One Phoenix Mill Lane, Peterborough, NH 03458, phone (603) 924-9281. Office hours: Monday through Thursday 8:30 AM—4:30 PM, Friday 8:30 AM—1:00 PM, Eastern Time. Address subscriptions to BYTE Subscriptions, 262 Old New Brunswick Rd., Piscataway, NJ 08854. Postmaster: send address changes, USPS Form 3579, undeliverable copies, and fulfillment questions to BYTE Subscriptions, 262 Old New Brunswick Rd., Piscataway, NJ 08854. Second-class postage paid at Peterborough, NH 03458 and additional mailing offices. Postage paid at Winnipeg, Manitoba. Registration number 9321. Subscriptions are $22 for one year $40 for two years, and $58 for three years in the U.S. and its possessions. In Canada and Mexico, $25 for one year, $45 for two years, $65 for three years. $69 for one year air delivery to Europe. 31,000 yen for one year air delivery to Japan, 15,600 yen for one year surface delivery to Japan, $37 surface delivery elsewhere. Air delivery to selected areas at additional rates upon request. Single copy price is $3.50 in the U.S. and its possessions, $4.25 in Canada and Mexico, $4.50 in Europe, and $5 elsewhere. Foreign subscriptions and sales should be remitted in U.S. funds drawn on a U.S. bank. Please allow six to eight weeks for delivery of first issue. Printed in the United States of America.

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

Subscription questions or problems should be addressed to: BYTE Subscriber Service, 262 Old New Brunswick Rd., Piscataway, NJ 08854.

Section art by John Cayea

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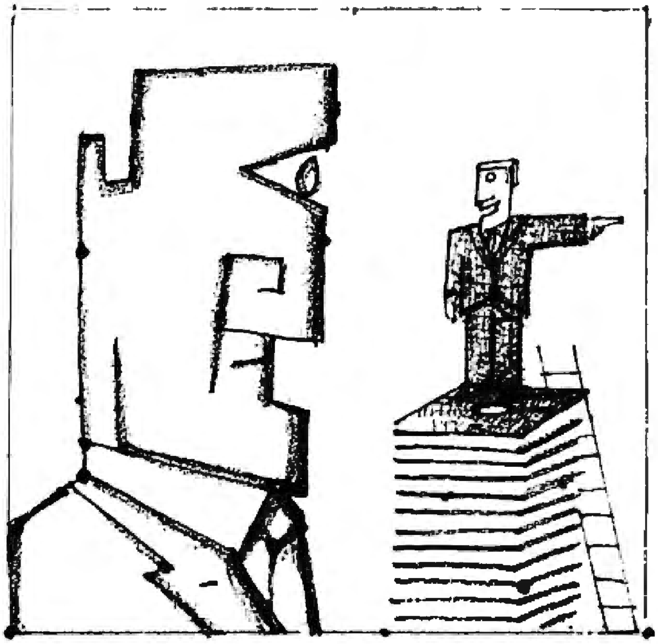
EDITORIAL



Intriguing Tales from the Early Days of the PS/2

Some companies in Austin, Texas, say IBM has been hiring workers away from their production lines to work in the PS/2 factory. Conclusion: The PS/2 machines must be selling well.

Another story out of Texas says that a major manufacturer of compatibles there, while publicly challenging the value of the PS/2 architecture, is privately videotaping the creation of its own PS/2 clones. The videotapes are to aid in the company's legal defense if IBM charges patent or copyright infringement.

A California card manufacturer has heard that IBM is offering clone makers licenses to PS/2 technology for $3 million or 1 percent of revenues. This is a single unconfirmed report that may be nothing more than a rumor, but it would be earthshaking for smaller companies if true.

Two general managers of a major card maker say that the Micro Channel bus will be hard to clone successfully. In order to ensure compatibility, they say, manufacturers will have to make almost exact copies, which will risk patent infringement.

Jay Bell of PC's Limited says duplicating the Micro Channel is difficult but not impossible. PC's Limited's 80386 machine outperformed all those tested thus far by BYTE on most benchmarks. However, the IBM PS/2 Model 80 was faster on a measure of I/O and on floating-point operations. IBM seems to have a monopoly on 80387 parts at this point, giving it a big edge on floating-point operations in the 80386 world. Manufacturers are looking hard at the Weitek floating-point chip set as an alternative to the 80387.

Tandy, pointing out that it already has patent exchange agreements with IBM, foresees no legal problems in making Micro Channel machines if it chooses to do so. But CEO John Roach also says the IBM software standard is what matters, not hardware. "We now can have very innovative hardware within the software standards," Roach adds.

Another card manufacturer says it will be required to use surface-mount technology to fit its circuity onto cards in the Micro Channel form factor. This will drive up costs. Furthermore, although the company would like to make 32-bit cards to maximize performance on the Micro Channel in the Model 80, the company will probably limit itself to a single line of cards for the Micro Channel—all 16-bit. Costs of doing two separate product lines are discouraging. The company contrasts this situation with the Apple Macintosh II and NuBus, which is a 32-bit bus only and has a larger form factor.

One major card maker in the IBM market is waiting for the Micro Channel to gain an installed base before developing products for it. Having been burned by developing products for the Convertible and the XT 286, this manufacturer is making a peripheral box for the Micro Channel that accepts XT and AT cards rather than a whole new set of Micro Channel cards.

The suggestion that IBM-compatible companies should standardize on NuBus rather than on Micro Channel looks more plausible all the time. This view, first advanced in print by Steve Gibson of *InfoWorld*, is supported by the higher performance of NuBus, the availability to all of the NuBus standard, and the suitability of NuBus for 80386-based systems as well as 68020-based systems.

Apple's commitment to NuBus guarantees a market of considerable size. Furthermore, many companies that formerly made products only for IBM machines are planning to make cards for the Macintosh II. If Tandy, Zenith, Compaq, or another major IBM-compatible manufacturer adopted NuBus rather than facing the legal issues of the Micro Channel, the NuBus market would suddenly look irresistible to many third parties.

The consensus in the industry is that Apple's Macintosh operating system will offer multitasking long before OS/2 has a Presentation Manager. Just as DEC has done in the minicomputer market, Apple may exploit the theme "Apple has it now" in the microcomputer market.

Furthermore, technical people at Ansa say that OS/2 users will need at least 3 megabytes of RAM. One megabyte will be required for the "compatibility box," and 2 megabytes will be needed to support the combined requirements of the Presentation Manager and multitasking. Memory is cheap, true, but the cost of very fast memory adds up before you reach 3 megabytes.

Increasingly, software developers who have concentrated on the IBM market are developing products for the Macintosh and Unix as well. Robert Carr of Ashton-Tate was one of the first to predict this trend. Ron Posner, president of Ansa, says, "We're definitely interested in the Mac. We're not only looking at the possibility of moving Paradox to the Mac, but also in acquiring Mac products. We want to put Paradox in as many environments as possible, especially where there's no product like Paradox." By the way, anyone who hasn't seen the network version of Paradox should take a look. Ansa has dramatically advanced the state of the art in multiuser network databases.

A spokesperson for Genoa, a maker of graphics cards and tape backup systems for IBM-compatible machines, warns that the VGA will be difficult to copy and expresses skepticism about products already claiming VGA compatibility.

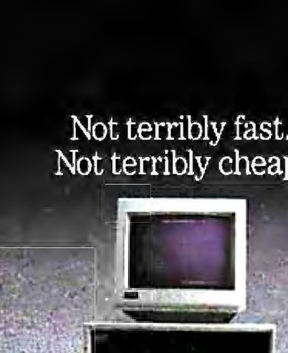
Despite occasional claims to the contrary, many IBM-compatible manufacturers are shifting to 3½-inch microfloppies as standard mass storage devices in future product lines. This change is long overdue.

—Phil Lemmons
Editor in Chief

Illustration by Maciek Albrecht

AND NOW, AN UNFAIR COMPARISON BETWEEN THE COMPAQ 386 AND THE NEW PC'S LIMITED 386[16]

Not terribly fast.
Not terribly cheap.



COMPAQ 386

In truth, any comparison between the two computers would be less than fair.

Because when we built our 386 machine, we didn't just copy what the other guys were doing, then throw in a few extra microchips for good measure; we built the industry's first true second-generation 386 computer.

Just take a look at how this baby performs.

Our proprietary 386 motherboard is less cluttered and utilizes Very Large Scale Integration and Static RAM. As a result, this machine has zero wait states, screams through compatible software, and blows the doors off Compaq's 386 on 16 and 32 bit instructions, mathematical calculations, sorting and memory read and write tests.*

Now take a look at the price. Because you buy directly from us, you bypass the middlemen —and their dealer markups. That means you can get our 386 for around $3,000 less than Compaq's.**

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So to all of you who already bought Compaq's 386, you have our condolences.

And to those of you who are thinking of buying one, you have our phone number:

1-800-426-5150.

*PC's Limited 386 Benchmark Study is available upon written request.

**Based on current suggested retail price, effective May 1st for most comparable system: Compaq Model 70 with a 70 Meg hard drive list price $8,699. PC's Limited 386[16] with a 70 Meg hard drive list price $5,399.

PC'S LIMITED 386[16]

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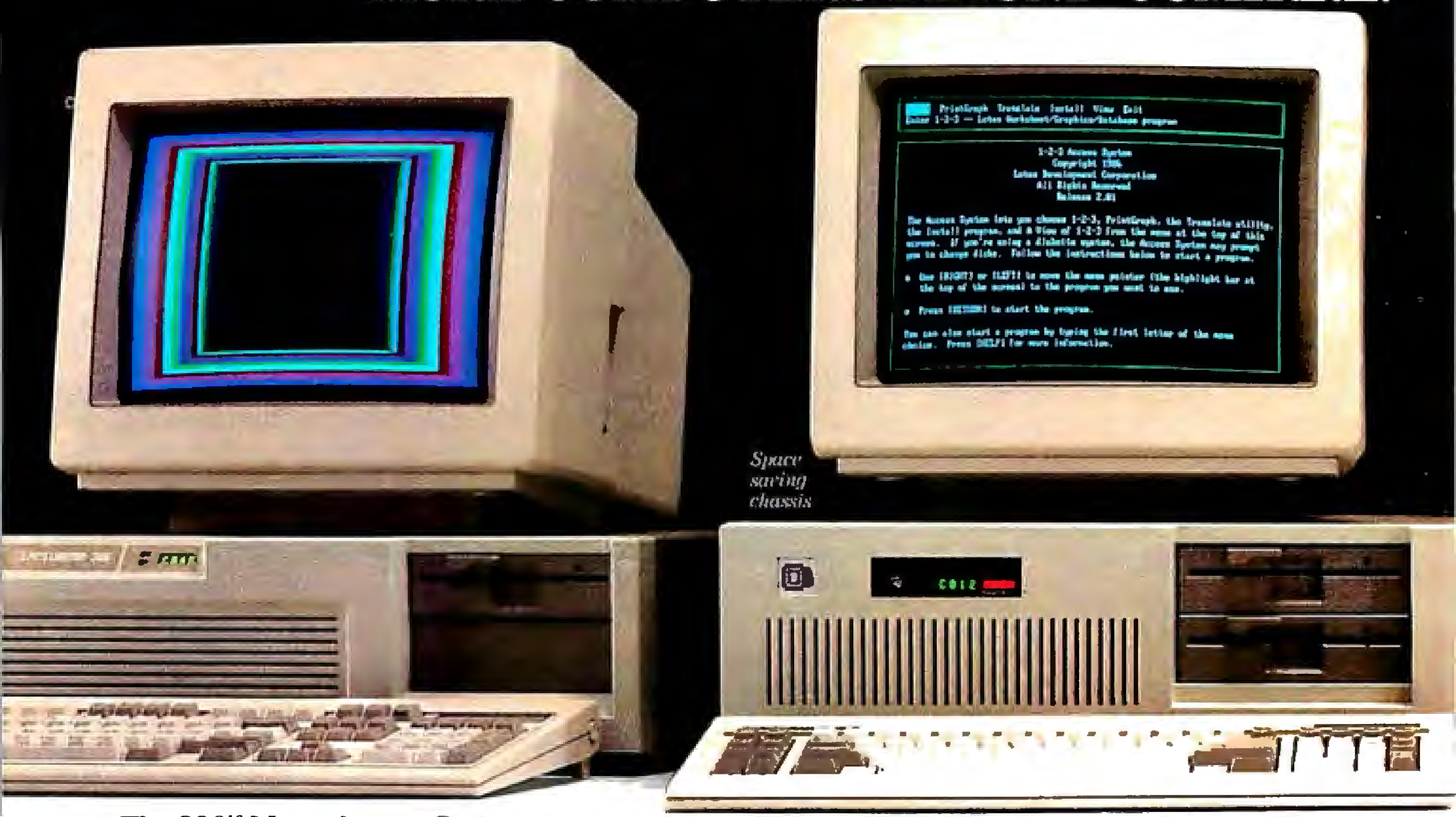

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High Resolution Monochrome Monitor
Standard chassis
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With one 360K floppy drive........................ $799
With one 360K floppy and a 20 Meg, 65 MS hard drive............................ $1,199

The Turbo EGA Color System

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With one 360K floppy drive and a 20 Meg, 65 MS hard drive.................... $1,699
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Inquiry 198

LETTERS

and Review Feedback

Outlining on Toshiba's T1100 Plus

Richard Brzustowicz Jr. (Review Feedback, May), referring to the review "Four Portable Computers" in the February BYTE, mentioned that he cannot use Microsoft Word's outlining facility on his Toshiba T1100 Plus laptop because the program needs number-pad plus and minus keys that are not accessible on his keyboard.

You can solve this problem by redefining the keyboard layout using SuperKey. The square brackets (ASCII 91 and 93) can be redefined as keypad plus and minus. You can use an AUTOEXEC.-BAT file to set this up.

T3100 users with hard disk organizers can have two AUTOEXEC files, AUTOEXEC.WRD and AUTOEXEC.ORD—one for Word and one for ordinary use. By menu, you can execute a .BAT file that copies the AUTOEXEC.WRD file to AUTOEXEC.BAT and executes a program (RESTART.BAT) to simulate pressing Control-Alt-Delete. Several have been published.

Frederick Colbourne
London, England

NCR Visibility

With reference to Stan Miastkowski's review "A Trio of 8-MHz PC AT Compatibles" (March), I was astonished at his statement that the nonstandard font used in the NCR PC8's character-generator ROM "made for sore eyes after a couple of hours."

This nonstandard font is based on a resolution of 640 by 400 in color mode, with an 8 by 16 character cell. I have used NCR computers for extended periods, and the display with its beautiful font, flicker-free display, and vivid bright colors is a big plus. The NCR display quality in text mode vastly surpasses both CGA and EGA quality.

With reference to his comment that the keyboard "has a decidedly cheap feel to it," I'd like to state that I use IBM, Epson, Kaypro, Apricot, Advance, and NCR microcomputers, and, based on my experience, the NCR keyboard with its unique style, features, and touch is the best among the crowd. It is solidly built, and its class and quality are impressive.

The NCR microcomputers have one problem—their high price tag. Apart from that, these solidly and thoughtfully built American computers deserve much more appreciation and attention from the microcomputer community.

Hamdy A. Ashour
Doha, Qatar

Tight Budget Drive

Your May review on Macintosh hard disk drives did not include a hard disk that meets my Best Buy criteria: the Easy Drive from DCC Systems (3921 East La Palma #N., Anaheim, CA 92807, (800) 345-0685).

Although leery of mail ordering, especially from a small manufacturer with no apparent track record, I took the plunge. Well, the hard disk arrived with a note stating that the instruction manual was not yet available. After recovering from the seizure induced by this information, I dialed the company with trembling fingers. Good sign number one: The phone was not disconnected. Good sign number two: The folks at the other end actually seemed to know what they were talking about. They insisted that the disk's installation and operations were straightforward, self-explanatory, and fail-safe. I began sweating again, but bravely turned on the drive. They were right. It worked as promised—simple and fast, and also quiet.

The hard disk uses plated media (Fuji), sits directly under the Macintosh, and has a two-foot SCSI cable, fan, and head park and backup utilities. It's an amazing deal for the Macintosh user with a tight budget and a need for expanded memory: 30 megabytes for $649.

Oh, yes—they did send the instruction manual, as promised. It's adequate.

Joel Potasznik
Mesquite, TX

Source Provided

Regarding the letters from Julie Sonack and Helen Emmons (May), I suggest two useful sources of information on computers and physically or mentally handicapped individuals:

Personal Computers and the Disabled, Peter McWilliams (New York: Quantam Press, Doubleday, 1984): an excellent, readable book, available in soft cover.

Proceedings of RESNA (Rehabilitation Engineering Society of North America): available in medical libraries, for more recent, detailed discussions by a variety of researchers and practitioners.

A. David Nawrocki
San Antonio, TX

BASIC Archimedes

In the letter "Easy as π" (May), John Godfrey gives algorithms that are "so simple and effective that they must have been discovered and published by others." They have. The discoverer's name was Archimedes (287–212 B.C.). Another version, which avoids FOR-NEXT loops, is:

```
10 PI#=2#
20 20#=SQR(S#+2#):P#=PI#:
   PI#= 2#*P#/S#
30 IF P#<>PI# THEN 20
   ELSE PRINT PI#
RUN
3.141592653589793
```

Klaus D. Mielenz
Gaithersburg, MD

I read John T. Godfrey's interesting code for generating an accurate value of π (Letters, May).

The integer ratio 355/113 gives a better value of a pseudo π than 22/7 when you are limited to a small hand-held calculator and not a fancy HP 15 or similar device. We used this ratio years ago in the Neanderthal age of computers on the Librascope LGP-30. I sometimes use it now for preliminary code development with MS BASIC in conjunction with spectral computations using the fast Fourier transform prior to converting to the faster Pascal.

Comparisons with a near-true value,
continued

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

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

such as Mr. Godfrey's and the Turbo Pascal π function, follow.

Values of π computed on Texas Instruments Professional Computer with Turbo Pascal-8087:

The value of pseudo π (355/113) is:

3.14159292035398E+000

The value of the Turbo Pascal π function is:

3.14159265358979E+000

The ratio of pseudo π to Turbo π is:

1.00000008491368E+000

The expected error (1 − pseudo π/Turbo π) is:

−8.49136787550719E−008

Value of π given by John T. Godfrey:

3.141592653589793

Thomas F. Marker
Albuquerque, NM

Search Routines

The article on hashing ["Look It Up Faster with Hashing," by Jon C. Snader, January BYTE] was very good, but one of the sugggestions could cause problems were it to be implemented.

The problem occurs in the suggestion that $j = 1 + h(\mathrm{KEY})$ be substituted for $j = (\mathrm{KEY} \bmod P') + 1$ to avoid a division that would be time-consuming on 8-bit computers. The trouble with this is, if $h(\mathrm{KEY}) = M - 1$ then $j = M$. If the entry at $h(\mathrm{KEY})$ is not blank and it is not what is being searched for, then j would be added to the index (which would equal $h(\mathrm{KEY})$), making it $2M - 1$. Because this is greater than M, M is subtracted from it, returning it to its original value of $M - 1$. The search routine would therefore loop around checking the same entry in the table continuously.

Riaz Seedat
Natal, South Africa

Challenge Accepted

We want to thank Denis G. Pelli for his excellent article on PostScript ["Programming in PostScript," May] and for mentioning our product, PostHaste, an interactive tool for programming PostScript on the Macintosh. That Dr. Pelli also took the time to write us an extensive personal letter containing many helpful suggestions impressed us greatly. His challenge to us to add some features to PostHaste to make it "superior to all the others, instead of just an inexpensive alternative" is having its desired effect—we intend to incorporate his suggestions posthaste!

continued

The A★Star
14
MEGAHERTZ 80286

For the benefit of BYTE readers, we would like to clarify a couple of points. Although PostHaste does not yet show error messages *as* they arrive, it does capture them and display them on the screen as soon as a program is finished uploading (we say *uploading* rather than *downloading* because the LaserWriter is actually a more powerful computer than the Mac). PostHaste also allows you to save the error messages to a file.

A unique feature of PostHaste, not mentioned in the article, is its ability to do partial uploads: selecting part of a file and sending just that portion to the printer. Another feature—apparently critical to many of our customers—is that PostHaste does not limit the size of files that can be uploaded to 32K bytes; file size is limited only by available memory. The $50 price mentioned in the article was an introductory price that ended May 1; the regular price for PostHaste is $59.95.

Thanks again to Dr. Pelli and to BYTE for an excellent article.

Joel Wysong
Micro Dynamics Ltd.
Silver Spring, MD

Upload Advice?

I would like to transfer files from a Xerox 630 Memory typewriter to a Hewlett-Packard Vectra microcomputer (MS-DOS 3.10) to edit them with WordStar. I tried Alien (a diskette conversion program), but it failed.

I wrote to HP for information, but I got no reply. Xerox replied, but was only able to tell me how to configure the typewriter as a printer from a microcomputer, using an RS-232C cable.

I wonder if you or any of your readers can suggest a solution to this problem. We are a bit short of technical information out here.

John McIntire
International Livestock Centre for Africa
P.O. Box 5689
Addis Ababa, Ethiopia

Distinctive Coloring

Mr. Pountain's ideas of what color combinations "work" ["Distinctive Coloring," April] may be more firmly based on physical factors than he thinks. On a color monitor tube with the three color phosphors arranged in a triangular pattern, a character that involves switching on just one color gun (red, green or blue) will appear sharper than a color requiring two or more guns.

Colors with a blue component will generally appear less sharp than those without, because the natural characteristics of the eye's lens bring blue to a shorter focus point than red, away from the retina. This is why we can pinpoint a red flashing light at night, but not a blue one; we can see it, but we cannot focus on it properly unless the vehicle under it is also visible, thus providing the eye with a focusing clue.

A graphics windowing system is capable of presenting far more information than the old 24 by 80 monochrome character display. With a partially hidden window, the information available on that window is being "hinted" at—you know the information is there, yet it is not immediately visible. As genuine multitasking environments become the norm, it might be interesting to see how one would go about color-coding the information and general environment. The coloring of individual windows might then become more important than the color-coding of the information *in* that window.

At any one time in a busy system, there will be more static, unchanging information than changing information. Too many colors and shades are just as confusing as too few. One can draw a parallel with modern aircraft cockpits. There is a huge amount of unchanging information available, and a change in status of an indicator may go unnoticed; hence the use of audio and visual attention getters. The visual cue is a flashing light at eye-level. Audio cues are a bit too much for the average computer user, but a visual attention-getter, such as flashing the affected window, could be useful.

Such usage goes a little beyond Dick Pountain's text highlighting, because it has to be a little bit interactive: Once the window has one's undivided attention, it must be possible to disable the cue, freeing it for the next event. Click the mouse, push the button, or whatever.

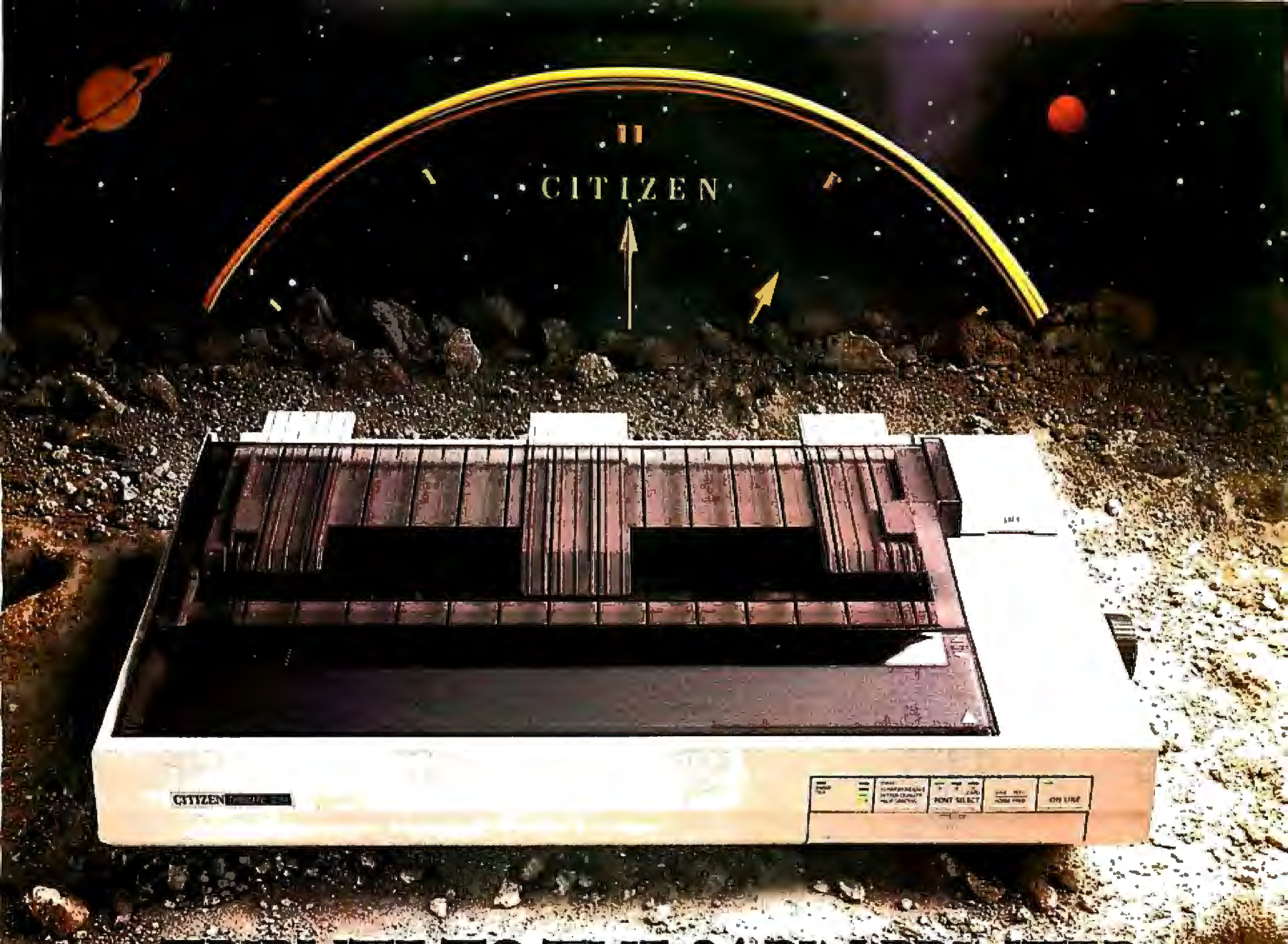
Paul Hardy
West Yorkshire, England

Using Rational Numbers

Regarding "Plotting the Mandelbrot Set," by Peter B. Schroeder (December 1986 BYTE): It is necessary to note that one never knows if a point belongs to the Mandelbrot set M; it is only possible to verify that a point is outside of it. But there is something else that nobody has pointed out (so far as I know):

M is computed in the complex plane C, so the calculations must be made with real numbers—but to do it practically we use computers and floating-point numbers, which means we are using *rational* numbers. Moreover, it is clear that we can find a point A very close to another point B, such that A belongs to M and B does not, and such that the distance between A and B is less than the precision of

continued



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Inquiry 46

the computer. That means that this problem is very sensitive to any digit in the digital representation of real numbers. Well then, floating-point representation makes a truncation; thus the elements calculated c, $c^2 + c$, $(c^2 + c)^2 + c$, . . . are not the "real" ones. It is possible, then, that although the calculated elements stay in M, the real ones "jump" outside.

I have, in fact, made experiments simulating precision of less than 32 bits. Far from the border nothing changes; but close to it, as foreseen, details change according to the precision. But there is a noticeable consistency: When zooming, large shapes subsist from frame to frame.

So what are we looking at—Mandelbrot set, or errors?

Jean-François Colonna
Palaiseau, France

Matrix Inversion

I draw the attention of the analysts among your readers to the fact that both the Pan-Reif and the Mackay methods you discussed in the April 1986 and February 1987 issues of BYTE are concerned with *iterative* methods for the solution of a system of linear equations or matrix inversion. However, for computers, I have a much more efficient *direct* method, the orthogonalization method. I published the basis of this method some time ago in the German publication *Wissenschaftliche Zeitschrift der Technischen Universität Dresden, 17* (1968), pages 1135–1136.

The earlier methods of solving a system of linear equations were mainly based on Gauss's ingenious idea of coordinate eliminating. Because of the choice of the prescribed coordinate axes, all these methods failed in degenerate cases (i.e., when the determinant vanished).

The new method makes the somewhat clumsy use of Kramer's rule and the various calculations of determinants superfluous. Thus, the orthogonalization method is interesting not only in computer solutions, but also in any form of high school teaching and application.

If you have a system of n equations containing n unknowns and a right-hand side, you may consider them represented by $n+1$ dimensional vectors each, having the coefficients of the equations as elements and -1 as the last element. Now a general entity of all of the variable real numbers is placed in an $n+1$ dimensional space. If these have to fulfill one of the above equations, you have to reduce the space to a subspace that is *orthogonal* to the vector representing this equation. This subspace was restricted in the Gauss-type elimination methods to a subspace of n dimensions orthogonal to one of the coordinate axes; here, no such specialization exists.

Then we take the next equation and reduce this subspace to a subspace orthogonal to the vector of this second equation. Since now the starting subspace is already orthogonal to the first one, the resulting subspace will be orthogonal to both of the two vectors.

So we continue the procedure; the end result will be in the general case a single vector as a subspace, with its first n elements the solution and the last element -1. That's the whole procedure.

Now the orthogonalization is a simple Schmidt orthogonalization. That is, we construct the scalar products of the rows of the matrix with the vector representing the equation in question and then search among them for any that do not vanish.

Let the ith row be represented by the vector $A_i(n+1)$; its scalar product with the vector of the equation in question shall be denoted S_i for $i=1,2, . . .,m$, where m is the number of the rows in the matrix of the present subspace. Let us suppose that S_{i0} is a nonvanishing scalar

continued

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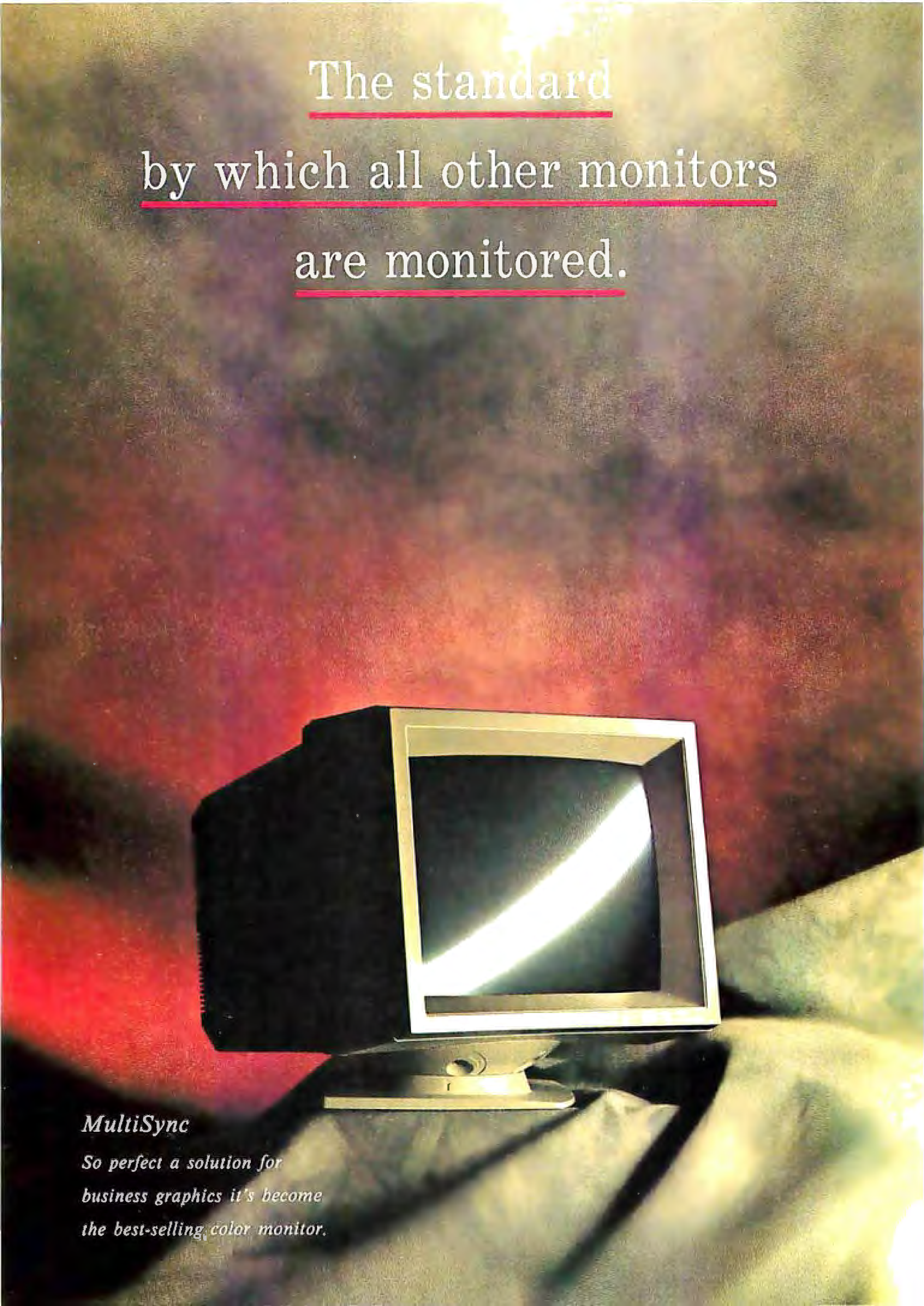
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product among them. Then we may reduce the m-row matrix to an $m-1$-row matrix by taking

$$A_i'(n+1) = A_i(n+1) - S_i A_{i0}(n+1)/S_{i0}$$
$$(i=1,2,\ldots,m, \text{ but } i \neq i0)$$

and neglecting the i0th row.

If no nonvanishing scalar product exists, then the subspace is already orthogonal to the equation in question, and the wanted subspace is the starting subspace in the last step itself. This denotes that the equation in question is already linearly depending on the earlier equations—there is a degeneracy. But now, unlike the earlier methods, you can continue the process without restriction, only the final dimension of the end matrix will be a $2 \times (n+1)$-dimensional matrix (two vectors) instead of the single $n+1$-dimensional vector. (Here the last vector has its last element -1, but the other one has its last element 0.)

This result supplies the general solution of the system: the vector of the last row plus the vector of the other row multiplied by any constant. The situation is similar if there are more dependent equations. If all the scalar products vanish except the last one, the system is contradictory (but we won't give the details here).

Now the scalar product is very simple to construct and amenable to parallel-processing.

You should also take into account that in the case of a scarce matrix (which is generally the case in the practice for large matrices), you may have to execute products with only the nonzero elements.

There is another remarkable point in this process. You use a row of the original matrix (i.e., one of the equations) once and only once. So, for instance, in a series of measurements you can immediately apply the data for evaluation and not store them at all. (This is an attractive use of the method, where data is collected and immediately processed—as in X-ray tomography, for example.)

The starting matrix can be either a unit matrix of size $(n+1) \times (n+1)$ or any preprocessed smaller size matrix (a subspace). For instance, if a series of systems of equations m $(m<n)$ of the equations are exactly the same in each system, you may start with these m equations once and follow each system separately from the resulting $(n+1-m) \times (n+1)$ matrix.

To summarize, the method does not fail even in degenerate cases, and so it also works well in ill-conditioned cases.

The running time is proportional to nk, where k is the number of nonzero elements in the matrix. The memory requirement is for matrix inversion at most n^2+1 storage places, and for the solution of a system of linear equations (with one right-hand side) $(n/2+1)^2$, decreasing very quickly if the matrix has many vanishing elements. (Here the storage of the original equations was excluded.)

The application of the method is advantageous anywhere matrix inversions or solutions of systems of linear equations arise, but it is especially favorable in Fourier-coefficient determination, regression analysis, finite-element calculations, and tomography programs. Protected programs based (partly) on this method are prepared for the Texas TI-59 and Hewlett-Packard HP-97. Linear programming and transportation problem solvers are in preparation for personal and high-performance computers.

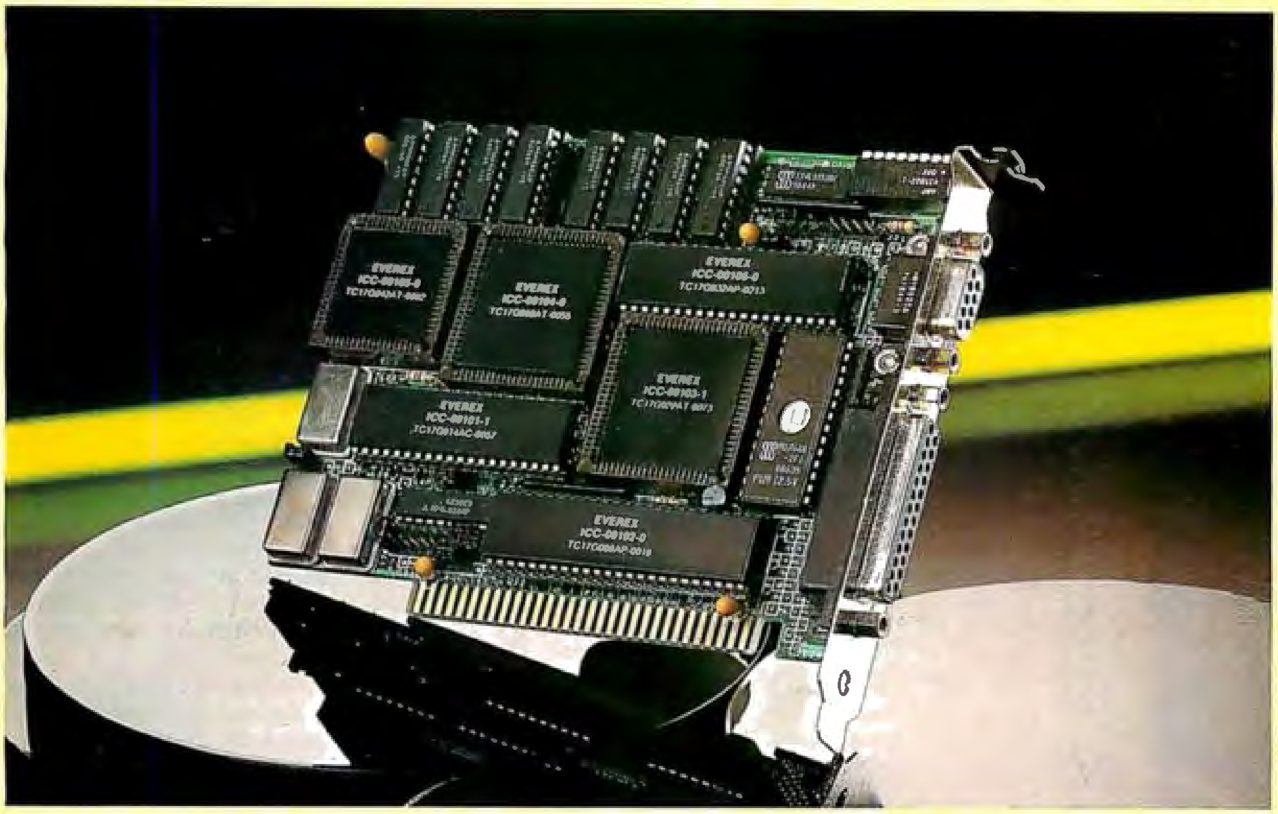
Tibor A. Hoffmann
Budapest, Hungary

Symbiotic VISC

I read with interest Phil Koopman's recent article on the WISC concept (April

continued

Everex ASIC Technology



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BYTE). I agree strongly with the opinions and design principles expressed in the article—so much so that I actually designed and manufactured such a machine, the RNA/32, back in 1983. While a few of the machines were sold, and three are still in operation, I was unable to acquire funding and the company (RNA Inc.) collapsed in 1985.

The RNA/32 was a 32-bit bit-slice (2901) user-microcodable machine. It had a byte-stream decoder for instructions, and each opcode byte was a direct jump into microcode (as Koopman suggests in his article). A 2048-word hardware push/pop stack formed the basis of a stack-organized instruction set, with the top-of-stack stored internally in the 2901.

Because of the convenience of implementing new instructions, the instruction set grew to reflect the high-level languages we supported. Set variables, dynamic strings, single- and double-precision floating point, procedure calls, and module linking were all represented by simple instructions. In addition, the compilers supported the replacement of any procedure call by a jump into microcode, so programs could be debugged in high level, then migrated to microcode.

Our data sheet claimed 5 million instructions per second and 400 thousand floating points per second, with a total workstation price of $25,000, including Winchester disk drive and 1024 by 800 pixel graphics. Bearing in mind that this was in 1983, you can see that the design principles espoused by Koopman can indeed generate cost-effective machines.

I am now readying a new product based on the same design principles. I have been using the acronym VISC, for Variable Instruction-Set Computer.

This one is configured as a "symbiotic" computer, relying on a PC host to do I/O. It is a pipelined 64-bit machine, with an 8K-byte by 128-bit 100-nanosecond microstore. The register file has remained at 2K bytes by 64, but it is now double-speed (35 ns) to drive the Weitek 2264/ 2265 (or BIT 2110/2120) floating-point unit at its full 20-mflop rate. A 32K-byte dual-port 100-ns static RAM forms the host interface, and two can be supported. The machine is built on a 12-inch by 15-inch circuit board, with a 5-inch by 12-inch piggyback holding up to 16 megabytes of four-way interleaved 64-bit wide dynamic RAM.

Robert G. Nelson
Nelson Computer Research Inc.
Sunol, CA

Random-Number Generators

To my surprise, neither the article "Testing Intrinsic Random-Number Generators" (January BYTE) nor the subsequent discussion of the article (Letters, May) tried to establish cycle length by inspecting the actual algorithms used. I found that BASIC uses a modified linear congruential sequence (see D. E. Knuth, *The Art of Computer Programming: Seminumerical Algorithms*, vol. 2, Reading, MA: Addison-Wesley, 1981), where:

$$R_{i+1} = (214016\,R_i + 13737667 - 3(R_i \bmod 65536)) \bmod 16777216$$

It is obvious that the period of this generator is at most 65536, because the formula can be simplified to:

$$R_{i+1} = (1024((209\,R_i \bmod 16384) + 13737667 - 3(R_i \bmod 65536)) \bmod 16777216.$$

The first random number is derived from the seed by the formula:

$$R_1 = (13321\,R_0 + 4317532) \bmod 16777216.$$

continued

The seed R_0 is in turn derived from the seed given as an integer in RANDOMIZE(X%) or typed in on demand after RANDOMIZE by:

$$R_0=256(x \bmod 256).$$

Thus, contrary to appearances (why ask for a number from −32768 through 32767), there are only 256 different random seeds. Moreover, as Modianos and his coauthors have already noted, the random sequence depends on the internal representation of the seed, not on its value, so there is a difference between X%=5:RANDOMIZE(X%) and X=5:RANDOMIZE(X).

The following BASIC program prints random numbers computed with this algorithm next to intrinsic random numbers:

```
100 REM RANDGEN
110 B1#=4317532!
120 A1#13321
130 B#=13737667#
140 A#=214016!
150 DEF FNM#(X#)=X#-INT(X#/M#)*M#
160 M#=16777216#
170 M2#=65536!
180 M1#=1073741824#
190 INPUT "HOW MANY RANDOM
    NUMBERS:";N
200 INPUT "RANDOM NUMBER
    SEED:";R0%
210 R0%=R0%-INT(R0%/256)*256
220 RANDOMIZE(R0%):R=RND(1)
230 R2#=FNM#(R0%*256*A1#+B1#)
240 FOR J=1 TO N
250 R=RND(1)-49/M1#
260 R2#=FNM#(R2#*A#+B#-3*
    (R2#-INT(R2#/M2#)*M2#))
270 PRINT USING "#.########
    #.########";R;R2#/M#
280 NEXT J

RUN

HOW MANY RANDOM NUMBERS: ? 10
RANDOM NUMBER SEED: ? 32050
0.28180980 0.28180975
0.61201040 0.61201036
0.82007800 0.82007796
0.61158560 0.61158562
0.91961880 0.91961879
0.94785080 0.94785082
0.05303508 0.05303508
0.16784120 0.16784120
0.50890870 0.50890869
0.41753000 0.41752994
OK
```

Rommert J. Casimir
Tilburg, The Netherlands

FIXES

Correction

In the May issue, the article "Make My Page," by Thom Holmes, gave an incorrect telephone number for Amgraf. The correct number is (816) 474-4797.

U.S. Address

Ernest R. Tello's review of Acquaint (in the June issue) did not include a U.S. address for Lithp Systems Inc. The company can be reached at:

Lithp Systems Inc.
32661 Belle Rd.
Avon Lake, OH 44012
(216) 933-5242

Benchmark Correction

In table 1 of "High-Tech Horsepower" (page 108 of the July issue), the benchmark results for the Deskpro 386 contained two errors. The result of the Fibonacci test should have been 53.10; the result of the Float test, 4.41. ■

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Inquiry 119

CHAOS MANOR MAIL

Conducted by Jerry Pournelle

Rapping WRITE, Kudos for KAMAS

Dear Jerry,

I am writing in response to your column in the February issue of BYTE. Although I have never used WordPerfect (I only use a CP/M machine), I take exception to some of your praise for WRITE. I purchased WRITE, partially because of your recommendation. It is easy to use, and it makes a nice composing tool when I am not composing in an outline processor. The problem is the WRITE manual, which has no index. The table of contents is not much help either, since it references only up to the five appendixes. No mention is made of the four addenda, although they are not even so called by page headings. To get the program to run, you have to use information at the back of the manual to know what the new program names are. A read.me file on disk would help.

WRITE is okay for printing, but it's not exceptional with a cut sheet feeder since it has no built-in way to transmit a form-feed symbol. This letter was written with Spellbinder, and I also use WordStar/NewWord. I guess that since you helped develop WRITE you obviously understand it well, and it *is* easy after you have figured out how to use it. I feel it had a rather steep learning curve for an easy-to-use program.

I also want to alert you to a working artificial intelligence program that will run on CP/M. The program is KAMAS, an outline processor and more. KAMAS has a menu mode that allows controlled stepping through the outline. As you go down in levels, only what would show under that selection is shown on the screen. It lets you step through a process very easily, much like an instruction book.

For each outline heading you can attach text so that, from the menu, explanations are available. You can easily add helps to each level, if necessary. If people need the help, they just give a command to view it. You are not forced to have more help than you want or need, and it is not in the way.

KAMAS is quite fast, and the program automatically makes all your available options into numbers from which you can choose. You can even back up a level if you decide you made an incorrect or inappropriate choice. The process is really effortless, and it surprises me that the manufacturer does not push this use of the product. Creating a full working AI system requires no more than laying out the outline format to solve the necessary problem, such as, "What disease does this patient have?" The main database I use comprises 256K bytes and fits on one disk. From what I've read, I'd need a very expensive machine to do the same thing without KAMAS.

I will admit to one problem with KAMAS: The manual (multiple volumes) is so large and detailed it is scary. The manual also makes only minimal mention of the AI capability, and then confuses the issue by stating that you could do it with either the menu mode or by writing a program to do it. Who would want to write a program to do what is already built in and instantly available?

George Richards
Rochester, NY

I always did say that WRITE was intended, and best, for creative writing. It's all right at formatting and printing, and things like that, and for a time was more than competitive in print features—indeed, for a CP/M system it still is.

But I agree that WordPerfect, and for that matter WordStar 4.0, have pretty well caught up with WRITE and in some ways passed it. I still use WRITE for creative writing because I am used to it; one day, though, I'll have to change over.

I looked in the Great Inventory Book (also known around here as Domesday), and apparently I have never had the KAMAS program you describe. Sorry. Sounds interesting.—Jerry

Praise for WordPerfect

Dear Jerry,

I read your comments about WordPerfect in the February issue. I am writing this to you with WordPerfect. So I must have been able to figure it out.

After you use the errata sheet and get WordPerfect installed (the copy *.* is a refreshing change of pace from the typical hyperencrypted wonders usually supplied for installation), here's the basic premise for learning WordPerfect. Put the template on the keyboard, which has the "delete word" keystroke on it, once one understands that "red" text indicates

continued

the Control key. Then do the first three lessons. Whenever you're stumped, depress F3.

I suspect that your version of WordPerfect isn't 4.2, the latest and greatest product from the software wizards of Utah. This version has another function in "DOS Text File Format" import that makes your carriage returns into soft carriage returns if the text extends into what WordPerfect calls the "H-Zone" (the area, which you can set, where WordPerfect checks for hyphenation). If WordPerfect Corporation reads your review, I assume you'll get an up-to-date copy.

WordPerfect has a lot of features crammed onto the 40 (counting the variations) function keys. It also has an unlimited (until you run out of disk space) number of main and special dictionaries. The 20 minutes required to remove words refers to the *main* dictionary, not the special dictionary (which you can edit with WordPerfect itself).

Once you figure out a certain capability, the hidden code for it is similarly obvious. When you do a font change, for example, the text is "Font Change," and so forth.

My final opinion on WordPerfect? It's as much an improvement over WordStar as WordStar is over Edlin. I'm still learning it, bit by bit, as I find a capability I need.

Charles L. Perrin
Madison, AL

I got a lot of letters about WordPerfect, and how you can make special dictionaries for it. Unlike Word Plus, the WordPerfect spell program makes you change manually from one dictionary to another; but it does work, and you can add your special upgrades to the main one if you like (or better yet, to a copy of the main dictionary; you can then rename it, and it becomes a special dictionary.)

When I began working with WordPerfect I didn't have 4.2, but I do now. WP is upgraded quite often, and inexpensively—a big plus for the company.

I've pretty much decided that WP will be the text editor I use for creative writing when I change over to a PC.—Jerry

Say Stabilant, Please

Dear Jerry,

Thank you once again for your kind mention of Tweek in BYTE. The last time I wrote was after your "Product of the Year" award. I enclosed several samples as well as a plea for a correction. I must assume that someone mislaid the samples and letter, either in the Canadian Postal System or at BYTE's editorial offices.

My company, D.W. Electrochemicals, manufactures this patented material and sells it throughout the world as Stabilant 22 (the concentrate that you reviewed a couple of years ago) and Stabilant 22a (an isopropyl-alcohol-diluted form). Sumiko Inc. (which owns the trademark Tweek) purchases the product from us in bulk and repackages and relabels it for distribution to the home audio field.

As I started work on this class of material in 1975, and as we have spent several hundred thousand dollars in R&D since that time, seeing some other company listed as the source (and by inference, the manufacturer) of the material is, to say the least, distressing. You would contribute greatly to our personal and corporate sanity if you could mention that we make the stuff.

We sell this material not only in the computer field, but also to radio and television stations, telephone and cable companies, and avionics and aircraft manufacturers (to name but a few customer areas); and we are NATO suppliers as well. At present we are the only company

continued

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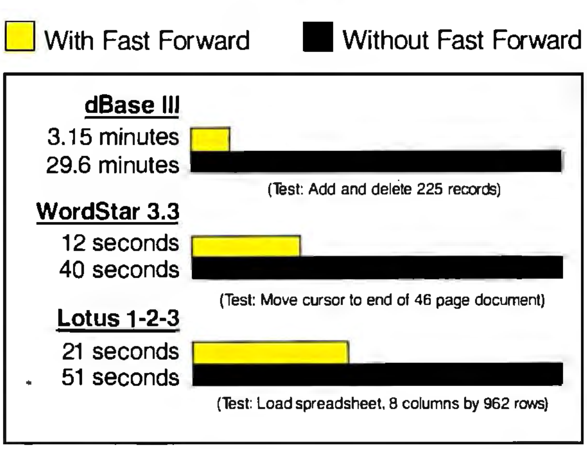

All tests done on 640K IBM PC, 20 megabyte hard disk and floppy drive. 320K RAM allocated to Fast Forward.

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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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You can buy a faster computer. Or an expensive accelerator board. But if you're ready to turn on the speed without turning over a bundle of money, ask for Fast Forward. It's from the Mark Williams Company, makers of quality software tools since 1976. And it's available at your software dealer. In the software department of your favorite bookstore. Or by calling 1-800-MWC-1700.*

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60-DAY MONEY-BACK GUARANTEE

making a material of this type.

We supply Stabilant in sizes of from ½ milliliter to 1 liter. The most popular form is a 15 ml Stabilant 22a service kit, retailing at about $36 U.S.; the 15 ml Stabilant 22 concentrate bottle retails at $54.50 U.S. Our address is:

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Richmond Hill
Ontario L4B 1G7, Canada
(416) 889-1522

Thank you again for the kind mention, I think.

William M. Wright, President
D. W. Electrochemicals
Ontario, Canada

Okay, and apologies. I first got the stuff as "Tweek," and it was as Tweek that I used it for a long time. When I got the package with two more bottles from you, either the difference wasn't clearly explained or I didn't notice.

Anyway, the stuff's wonderful. I just used it to lubricate the gate array for inserting a math chip into the Kaypro 386. Indeed, it goes on nearly everything I put into the computers. I suppose I ought to try it on my hi-fi stuff, too. Oddly enough I never thought of that.—Jerry

Atari or Amiga for Videos?

Dear Jerry,

I am going to buy a new computer system to assist in the production of educational videotapes. I need hardware and software that will let me transfer images from videotape to the computer monitor, manipulate the image in a virtually unlimited number of ways, insert animation sequences, and then transfer it all back to the videotape.

At the end of your article in the March issue you mentioned some "really impressive" new software for the Atari ST that helped make the ST "the real hit of COMDEX." I have looked seriously at both the ST1040 and the Amiga 1000.

Also in the March BYTE there is a preview of the Amiga 2000. Instead of breaking new ground, Commodore appears to have stood pat in many respects. I'm willing to wait a little longer if Atari has something up its sleeve.

Francis Louis Szot
Miami, FL

Well, what I saw at the Consumer Electronic Show was not the machine that Commodore brought out as the 2000; what I saw was more advanced.

I think Commodore could and should have made a quantum leap by bringing out a machine with a 68020, a math chip, and an 80286 (or maybe even a 386) on the DOS side. That would have been a really stunning machine.

Most DOS users find their PCs rather boring; the chance to add the Amiga's graphics while preserving the option to run all their current DOS software, and still get a new state-of-the-art machine, would in my judgment have attracted much of the business world.

Of course it's easy for people like me to say what kind of risks companies like Commodore ought to take.—Jerry

He Likes His Toshiba

Dear Jerry,

I have followed with interest your remarks about laptop computers. I am currently enjoying a wonderful warm Sunday out on a rooftop sundeck, in complete control of WordPerfect on a Toshiba T1100 Plus. My little Toshiba is almost all I could ask for in a computer: It runs all my software, the keyboard is quite usable, the display is better than any ex-

continued on page 268

We Do Windows

Choose from a Complete Family of Windows compatible Graphics Applications.

Micrografx is the premier developer of graphics applications compatible with Microsoft Windows. And Windows DRAW, Windows GRAPH, and In*a*Vision are recognized as the leading graphics applications in the industry.

Windows DRAW is a business drawing and presentation graphics program, which includes over 1000 predefined clip art images. Windows DRAW was rated as the number one free-form graphics program by Software Digest (Dec., 1986) and is sold internationally by Microsoft.

Windows GRAPH is a business graphics and charting program, and is the newest member of the Micrografx family. With Windows GRAPH, you can create an unlimited variety of area, bar, column, line, pie, scatter, combination, and table graphs. Use existing spreadsheet data or enter data directly to create a stunning array of two- and three-dimensional color graphics. Then enhance your charts with free-form drawings, multi-font text and clip art.

In*a*Vision is a powerful, easy-to-use Computer Aided Design (CAD) program. In*a*Vision was the first Windows-compatible program and according to PC Magazine (June, 1987), "In*a*Vision is still the best Windows-specific application." In*a*Vision is ideal for design professionals. Whether you are creating complex technical drawings, schematics, flowcharts, floor plans, organization charts or designing your own new kitchen, In*a*Vision makes your job easier.

Each Micrografx application is compatible with Microsoft Windows. And compatibility with Windows today guarantees an easy upgrade path to the Windows of tomorrow.

With Windows, each Micrografx application can run in a window simultaneously with any other Windows application. And Micrografx' applications are data compatible with all other Windows applications through the Windows Clipboard. A common user-interface, pull-down menus, mouse support, shared device drivers and our common "object-oriented" file structure gives you consistent ease-of-use and top-quality output. Our PostScript and PageMaker compatibility means that all of the graphics you create are perfect for desktop and professional publishing.

In addition, Micrografx offers Windows ClipArt with over 1000 business-oriented images and CAD ClipArt with over 1000 images from the architectural, electrical, chemical, and mechanical engineering fields. And through Windows CONVERT, your graphics are fully compatible with the AutoCAD data exchange format (DXF).

For additional information about how to put Micrografx to work for you, call your local authorized dealer, or contact Micrografx toll-free, at **800-272-DRAW** (in Texas 214-234-1769) or write to Micrografx Inc., 1820 N. Greenville Ave., Richardson Texas 75081. Call today and let Micrografx take the dirty work out of doing Windows.

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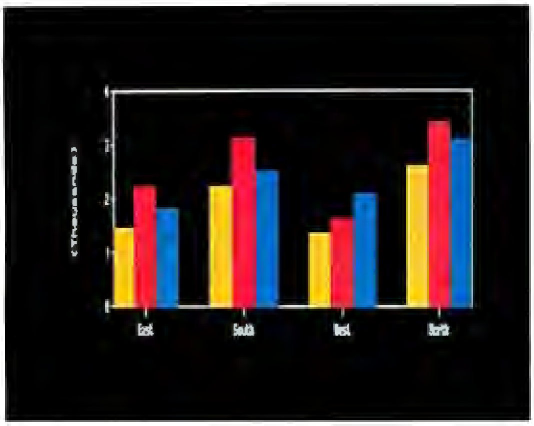
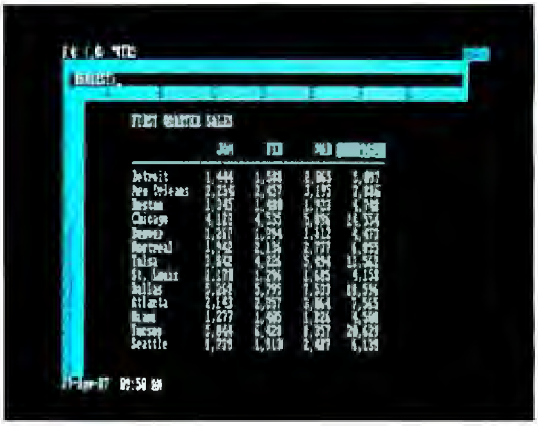
Supports the new IBM PS/2 standard

Inquiry 159

To get Lotus 1-2-3 to do all this more quickly and easily, we didn't make it more powerful.



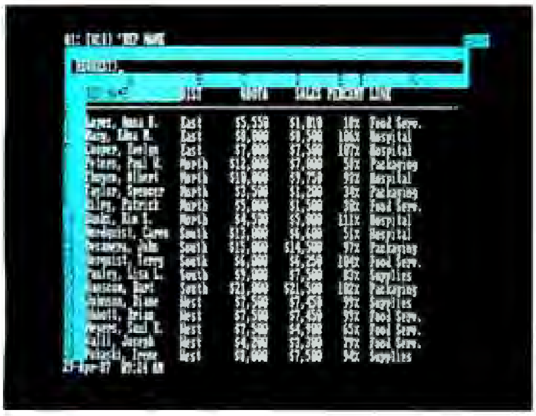
Lotus HAL doesn't change 1-2-3 or the worksheet. It makes things easier. For instance, to graph sales by district from January to March just request "graph Jan to Mar."



You can spend a lot of time setting up your spreadsheet. Summing up sales figures is a good example. With Lotus HAL, just request "total all rows" and 1-2-3 and Lotus HAL will create the formulas.

Say you want to extract just the information you want from a database. For example, you want to determine your top sales reps. Simply request "who has sales ≥ 8000."

You may find yourself in the position of figuring out how a spreadsheet was built. Well, with Lotus HAL, you simply request "list the relations in the sheet." And away you go.



Do you find it hard to sort things by district or sales or any other criteria? Just request "sort by dist."

To create macros, well, you may not believe this. What you see here isn't a description of what's happening—it's the actual macro. See, we told you you wouldn't believe this.

We made you more powerful.

How? With Lotus HAL™—a Companion product for 1-2-3® that helps you take shortcuts, undo mistakes, link spreadsheets, use your own words for commands and basically get more out of 1-2-3 than ever.

So much more, that Computerworld has named Lotus HAL "Product of the Year."

The screens on the left will give you an idea of how easy it is to get more out of 1-2-3. And these are only a few of the enhancements and new features Lotus HAL brings to 1-2-3.

Lotus HAL gives you the ability to perform 1-2-3 tasks using simple English phrases—called, logically enough, "requests." This has advantages for all kinds of 1-2-3 users: the newer users will find that difficult tasks are now simplified; the more experienced users will find that many time-consuming tasks can now be performed in a fraction of the time.

In addition to this powerful capability, Lotus HAL also allows you to test assumptions, correct mistakes and simply change your mind with ease. Because through a special capability called "undo," Lotus HAL lets you reverse your last command—even retrieving a file before saving your work.

Besides all this, Lotus HAL gives 1-2-3 a number of other useful and powerful new features—like spreadsheet auditing and the ability to link cells or ranges between worksheets.

One obvious benefit of all this is that you save time. This is what led Business Software to say, "...(Lotus) HAL gives users the ability to move through 1-2-3 at least twice as fast."

And what does that savings in time mean to a business person? It means you're more powerful, more productive, more effective than ever before.

Make yourself more powerful, and buy yourself Lotus HAL. You'll find it at your Authorized Lotus Dealer, for just $150.* Or, you can call us directly at 1-800-345-1043 and ask for Product YG-1377, or ask for YG-1385 to receive more information about Lotus HAL. See? Everything with Lotus HAL begins with a simple request.

Lotus HAL

Requirements: Lotus HAL is a memory-resident program that requires 1-2-3 Release 1A, Release 2, or Release 2.01 for personal computers from IBM,** COMPAQ and AT&T, plus 1-2-3 certified compatibles; two disk drives; DOS 2.0 to 3.1; 512K RAM. Please refer to your 1-2-3 package or 1-2-3 documentation for appropriate hardware configurations and DOS requirements or consult your dealer. **Lotus HAL does not operate with 1-2-3 for IBM PCjr., or IBM PC Convertible or Release 1A for the IBM 3270PC. When you purchase Lotus HAL directly from Lotus, take your first 30 days to try it. If after 30 days, Lotus HAL does not perform as described and you've purchased it directly from Lotus, we'll gladly give you a full refund.

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MICROBYTES

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

Logic Distributed Among Chips Makes PS/2 Tough to Crack

As suspected, cloning an IBM PS/2 may not be quite so easy as cloning a standard PC, hardware manufacturers are finding out. The problem, they say, is that IBM has distributed logic among several different arrays and chips on the motherboard instead of confining it to a single location. Consequently, "it isn't clear where the individual functions are—in the firmware, software, hardware, or eventually maybe in add-in cards," one industry source told Microbytes Daily.

Morris Jones, vice president of technology for Chips & Technologies (Milpitas, CA), concurred, stating that "there is a lot of logic in the chips that isn't talked about in technical manuals." Jones said that "in order to implement a fully compatible PS/2 system, you are going to have to fully understand that system," stating bluntly that "you can't just blindly reverse-engineer a PS/2 and copy it."

Jones also said it isn't clear at this point what IBM has in mind for some of the PS/2 functions, saying "we haven't seen the big picture yet." As an example, Jones pointed to the bus that, unlike that of the IBM PC AT, allows a coprocessor to talk directly to all the peripherals. This indicates, Jones speculated, that "IBM has put a lot of emphasis on future products," and that hardware manufacturers haven't been told what those products might be or how they might work.

Another expert said, "You have to look at the system as a whole—the DMA, the graphics chip, even the hard disk controller—and know where every gate is and what it does." If a manufacturer finds DMA-related code in two chips, for instance, and does not continue looking elsewhere for additional DMA information, something can be missed, with the result that the system may not work. "Anybody who doesn't get down to the last gate is probably missing something," he said.

Tandy Chief Sees No Obstacles to Cloning New Bus

Tandy (Fort Worth, TX) chief John Roach said he sees no major technological—or legal—obstacles to cloning IBM's new bus. Talking to a group of reporters and financial analysts, he also said Tandy will emphasize software rather than hardware compatibility with IBM's new Micro Channel architecture. Other Tandy officials mentioned that Tandy had licensed a number of IBM patents in the past, and that IBM had licensed some of Tandy's patents. Roach said the Micro Channel architecture is impressive but that Tandy will probably continue to use the AT bus because of the large number of boards that are compatible with it.

Roach emphasized that the projected OS/2 operating system will run on Tandy's 80286-based computers, including the 3000 HL (which Tandy just cut in price by $400, to $1299 for a one-floppy system). When equipped with features comparable to the new IBM Model 50, the 3000 HL will cost about $1000 less than the IBM unit, Tandy says. Roach said Tandy has a faster hard disk drive than the IBM machine has. So, although the Model 50 is slightly faster than the 3000 HL, the faster disk drive of the 3000 HL makes the two machines equal in performance, Tandy claims. Roach decried IBM for not allowing internal 5¼-inch drives in the new PS/2s. Tandy will have its own 1.4-megabyte floppy disk drives available in a few months.

According to John Patterson, Tandy's vice president of research and development, the 256,000-color palette of the VGA is provided by an off-the-shelf Inmos chip. Roach said Tandy expects to have a VGA board available in a few months. But he said it may take longer to get VGA monitors into the marketplace.

Patterson mentioned that, at 8

continued

Nanobytes

"A lot of companies are still trying to figure out what to do with OS/2," **Paul Grayson**, CEO of **Micrografx** (Richardson, TX), told us during a demo of Windows Graph (which runs under Microsoft Windows and generates object-oriented graphics). Grayson said that simply porting programs to the projected operating system will not be a profitable strategy. "Users will not convert to OS/2 simply because it's a new operating system. They must have a reason to use OS/2 and the new hardware. They will need to have solutions which require OS/2," Grayson said. . . . **Silicon Beach Software** (San Diego, CA) offered a sneak peak at its "Super3D" color modeling program at the New York Macintosh Users Group's MacFair. The "enhanced" edition of the program was running on a Mac II, but a less powerful version will run on 512E or higher Macs. Prices tentatively are $495 (offers color and use of the 68881 coprocessor) and $295 (black and white only). **Charlie Jackson**, president of Silicon Beach, would say only that the program will ship "after we've stomped on all the bugs we can find in it." . . . **VLSI Technology** (San Jose, CA) says its IBM PC AT-compatible chip set should help bring down prices in the PC market. The company claims its five-chip combo cuts the number of nonmemory devices in AT-like machines from 110 to 16. The devices include a peripheral controller, system controller, memory controller, address buffer, and data buffer. OEMs can add their features easily because the set was designed with a "building block," or megacell, approach, VLSI says. Production on a big scale is ex-

continued

pected by the third quarter. . . . Modem maker **USRobotics** (Skokie, IL) is supplying **Data Race** (San Antonio, TX) with source code and schematics in exchange for rights to some proprietary technology relating to a patented error-protected modem design. Data Race will be able to build a 9600-bps dial-up modem that's compatible with USRobotics' Courier HST modem, and the two companies expect to be able to get their respective modem models to communicate. . . . At the JEIDA Microcomputer Show in Tokyo, **Sanyo** (Osaka, Japan) introduced a color LCD with a matrix resolution of 960 by 200, which translates to 320 by 200 RGB pixels. To get the red, green, and blue, the system uses nonmoveable filters arranged in a pattern similar to that used in most color television tubes. The display is about 30 to 40mm thick. . . . At that same show in Tokyo, **Sharp** (also of Osaka) rolled out an electroluminescent flat-panel display with a resolution of 640 by 400 dots. We didn't verify this with a teeny-weeny ruler, but Sharp said each pixel measures 0.22mm by 0.22mm, with a pitch of 0.3mm. . . . **Mitsubishi** (Tokyo) formally announced its intentions to support the **TRON** project with a 32-bit CMOS microprocessor that will use a proprietary object code format and a non-multiplexed bus. The company said the chip will run at 20 MHz, perform 4.5 to 12 MIPS, and be able to run Unix, C, assembly language, simulation software (for debugging), and the TRON OS. . . . **Fujitsu** (Tokyo) also announced a forthcoming product: a 1-megabyte EPROM chip set. . . . Here's the scenario for the **CD-I** (compact disc-interactive) scene as described by speakers at a recent conference in San Francisco: 1988 will be a year of experimentation and development; 1989, maybe 1990, will be the first year of serious applications development; by 1992, system prices will be down to $500 and software below $50. One speaker pointed out that getting hardware prices down to $500 will be "a nontrivial task."

MHz, the minimum cycle time for the DMA on the Micro Channel bus is more than twice as fast as that on the AT bus. He said the speedup is due to special hardware and may be important for use with OS/2. The DMA capability, however, is limited to a 16-bit width. Patterson also mentioned that the 32-bit version of the Micro Channel bus is apparently only for use by memory, because on a fully configured PS/2 Model 80 the three 32-bit slots would have to be occupied by memory cards. Thus many manufacturers would probably follow Compaq's example and choose to use a proprietary 32-bit bus intended solely for that company's memory cards.

Roach wouldn't talk about the rumored 386 machine and laser printer (well, they were still rumors at press time), but he did say his company will be coming out with a home-oriented system that's so simple "my wife could use it without reading the manual."

PS/2 Bus, Ports Pose Problems for Board Makers

Makers of add-in boards are discovering that designing products for the new IBM PS/2 systems is a whole new ball game. Not only are those I/O ports built directly into the motherboard, in many cases making a need for add-ins questionable, but also the design of the system itself is making the job more difficult than it has been to build boards for existing PCs. Some add-in board designers say major issues to be dealt with include mastering the bus, the prevalence of shared interrupts, and how signals are interrupted by boards and the bus. "The challenge," said Richard Rohlf of AST Research (Irvine, CA), "is having to learn the bus all over again."

Matt Zuckerman, president of Advanced Transducer Devices (Sunnyvale, CA), told Microbytes Daily that the PS/2 systems are "very sophisticated in the way they integrate the BIOS in the architecture." He explained that when the system is turned on, calls are made to the BIOS so diagnostics can be performed on the various I/O ports. It is very difficult, if not impossible, he said, for standard add-in multifunctional boards to be diagnosed in the same way that the PS/2 performs diagnostics.

Zuckerman also said the powerful bidirectional parallel port on the PS/2 is another difficult issue that add-in board companies must contend with.

Electronic Distribution Method Would Hinder Piracy, Japanese Say

Japanese companies are working on a new method of software distribution that is designed to eliminate software piracy and make software as easily accessible "as water or electricity." The Software Service System (SSS) is an electronic proprietary method invented by Ryoichi Mori. Mori is the chairman of the Microcomputer Committee of the Japan Electronics Industry Development Association (JEIDA), the organization that also originated the Fifth Generation and TRON projects.

The SSS is an elaborate access-control system whose primary component is a so-called SSS box that attaches to existing computers—or more importantly, that could be inexpensively incorporated into new computers using custom VLSI. Under the plan, software could be freely copied or distributed via radio or other sources but would not run until the SSS box gave permission.

The user would purchase a special IC card (smart card) to activate the SSS box. The card would contain "common credit" that could be applied to any software the user wanted to buy. The card would also maintain a record of the software used. The common credit distributor would use this information in forwarding payments to the software houses.

Hardware manufacturers would be enticed to incorporate the SSS box into their computers by receiving a 5 percent royalty on common credit purchases. Software houses, of course, would receive most of the payment, and the distributor would also make a profit.

According to Mori, the system will be attractive to software developers because computers incorporating the SSS box would virtually eliminate unauthorized software use, which could lead to lower software prices. And since

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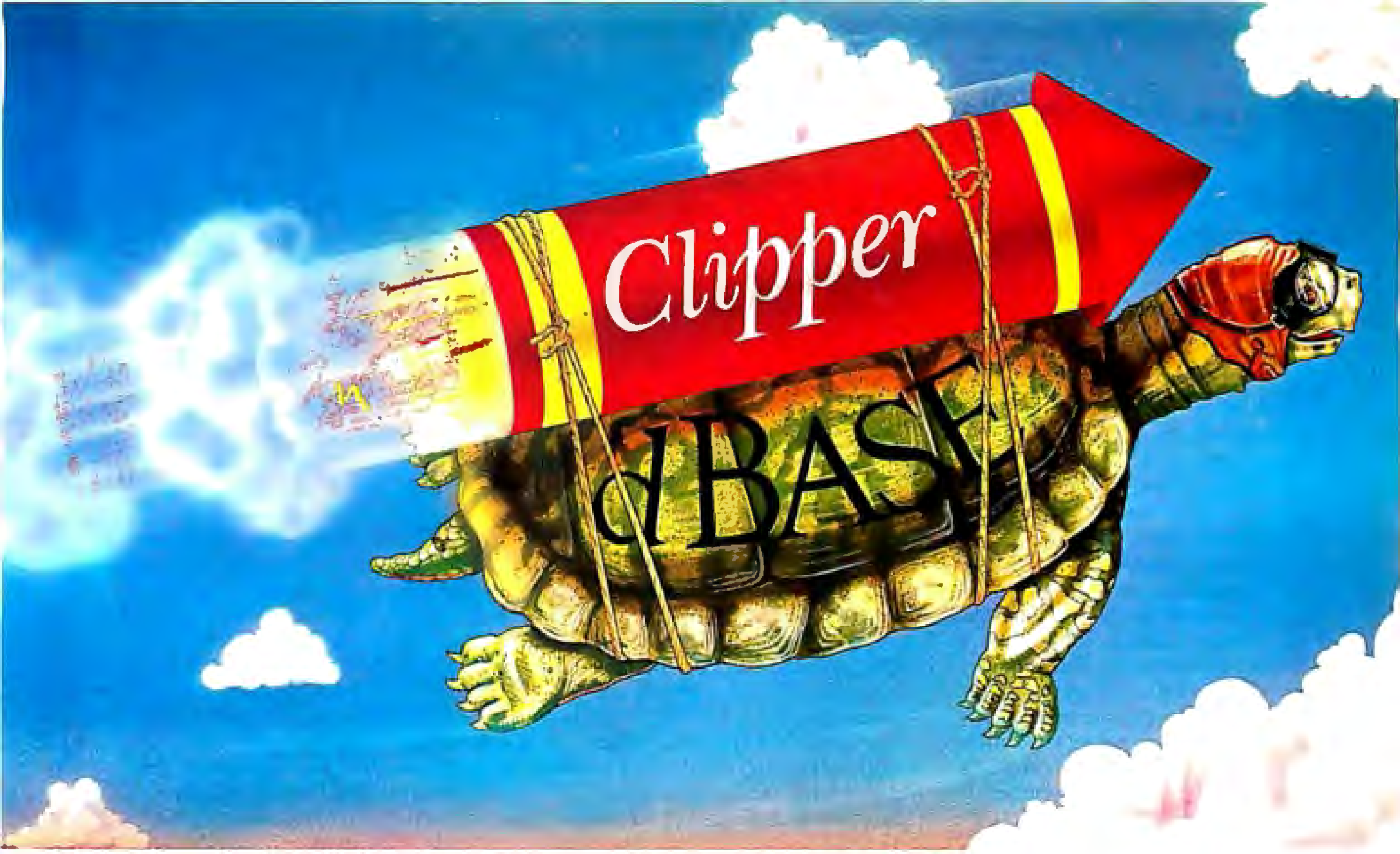

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Inquiry 177 for End-Users. Inquiry 178 for DEALERS ONLY.

software use would be restricted by hardware, users would in fact be encouraged to copy software and distribute it to friends, he said.

The system would also allow mass distribution of software on CD-ROM, where the disc could contain hundreds of programs and would sell for little more than the production cost—perhaps as little as three or four dollars. The user would use the common credit on the IC card to pay only for the software he or she actually uses.

According to Mori, all the major Japanese microcomputer companies are currently investigating ways to implement SSS, but he added that more work remains to be done.

BBS Gives the People a "Conduit" to Legislators

The California State Assembly (Sacramento) recently switched on an electronic bulletin board system intended to provide, in the words of assemblywoman Gwen Moore, "a way of extending to the general public information and participation in government." The BBS, called the Capitol Connection, is a pilot project sponsored by the Utilities and Commerce Committee.

Initially the BBS consists of three sections, two of which are read-only: One concerns issues before the committee, and the other contains abstracts of bills before the entire legislature. The third area has two main topics: telecomputing, which focuses on the impact of personal computers and telecommunications on society; and technocivics, dealing with the influence of technology on politics (and vice versa). The system also lists names and phone numbers of state representatives and will eventually provide electronic mail access to those individuals.

Bob Jacobson, principal consultant to the Utilities and Commerce Committee, told Microbytes that "this is the first one [BBS] we know of that is focused on policy issues per se and gives constituents a direct conduit to members of the assembly. We are working to shrink the distance between constituents and the legislature." Jacobson said the Capitol Connection is "a bipartisan system," and that in the future both Democrats and Republicans may have their own subconferences on particular issues.

The system is built around a Compaq Deskpro 286 tied to four phone lines via 1200-bps modems. The software is a Caucus BBS package running under SCO Xenix. If the project is successful (and Jacobson says that "we don't really know what successful means at this time"), the committee will look into adapting it to the DEC mainframe currently being installed in the assembly, provided security measures can be designed to keep the public out of confidential assembly business.

For the most part, legislators have backed the BBS, which has been paid for out of the committee's contingency funds. "The Speaker [Speaker of the Assembly Willie Brown] is very much into office automation," Jacobson said, "and he loves this concept."

Optical Devices Seen as Big Part of Future Desktop Publishing

Desktop publishers will be seeing heavier use of optical disks and scanners, software that can handle much longer documents, and synthetic paint programs that will let them draw with a pencil instead of "a brick," speakers told a DTP conference recently. Paul Brainerd, president of Seattle-based Aldus (which makes PageMaker), said most desktop publishing software can now work with documents of more than 100 pages, a number that has increased rapidly from the 16-page limit of a year ago.

Brainerd predicted much heavier use of optical scanners for reading text and graphics from printed sources into publishing systems. In conjunction with scanners, CD-ROM and optical disk storage will allow development of large databases of graphics images, similar to the clip files kept by newspapers. Electronic communication within companies and satellite offices will greatly increase the distribution of "electronic newsletters" created with desktop publishing systems, Brainerd said.

John Warnock, developer of the PostScript page-description language and cofounder of Adobe Systems (Palo Alto, CA), predicted that WYSIWYG page layout programs and document-compiler–type programs would merge in the near future, giving users the control and database facilities of the document compiler combined with the flexibility and ease of use of the WYSIWYG-type approach. Warnock, discussing paint graphics programs and synthetic graphics programs (programs that can work with optically scanned images, such as Adobe Illustrator), said that paint graphics programs will switch from using bit-mapped data to using gray-scale data. Synthetic graphics programs will become more popular "because drawing with a mouse is like drawing with a brick," he said. With a synthetic graphics program like Adobe Illustrator, you can draw with a pencil and then use an optical scanner to read the image into the graphics program, said Warnock. He concluded that desktop publishing programs will become increasingly device-independent.

Bruce Gitlin of Xerox (Rochester, NY) said the typical desktop publishing machine will feature a 19-inch display with 1024 by 1024 resolution, 16 levels of gray (with an option of as many as 256), 2 megabytes of main memory, and 1 to 3 MIPS.

Gitlin also predicted that LANs will play an important role in departmental and work-group publishing. However, wider network bandwidths will be required, said Gitlin, and those will be supplied by fiber-optic links transmitting 50 to 100 megabits per second. He stressed the importance of optical storage in providing a means for secondary and future use of printed information. Scanning is the bridge between the printed and the electronic document, Gitlin said.

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.*

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

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

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Ventura Publisher
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Frontpage
DeskSet
Pagemaster
Rim Systems
Compound Document Processor
Display Ad Make-up System

COMPUTER-AIDED DESIGN
AutoCAD
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MS-Windows
GEM
MetaWindows
HALO
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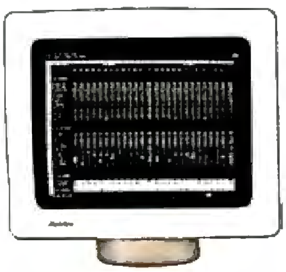

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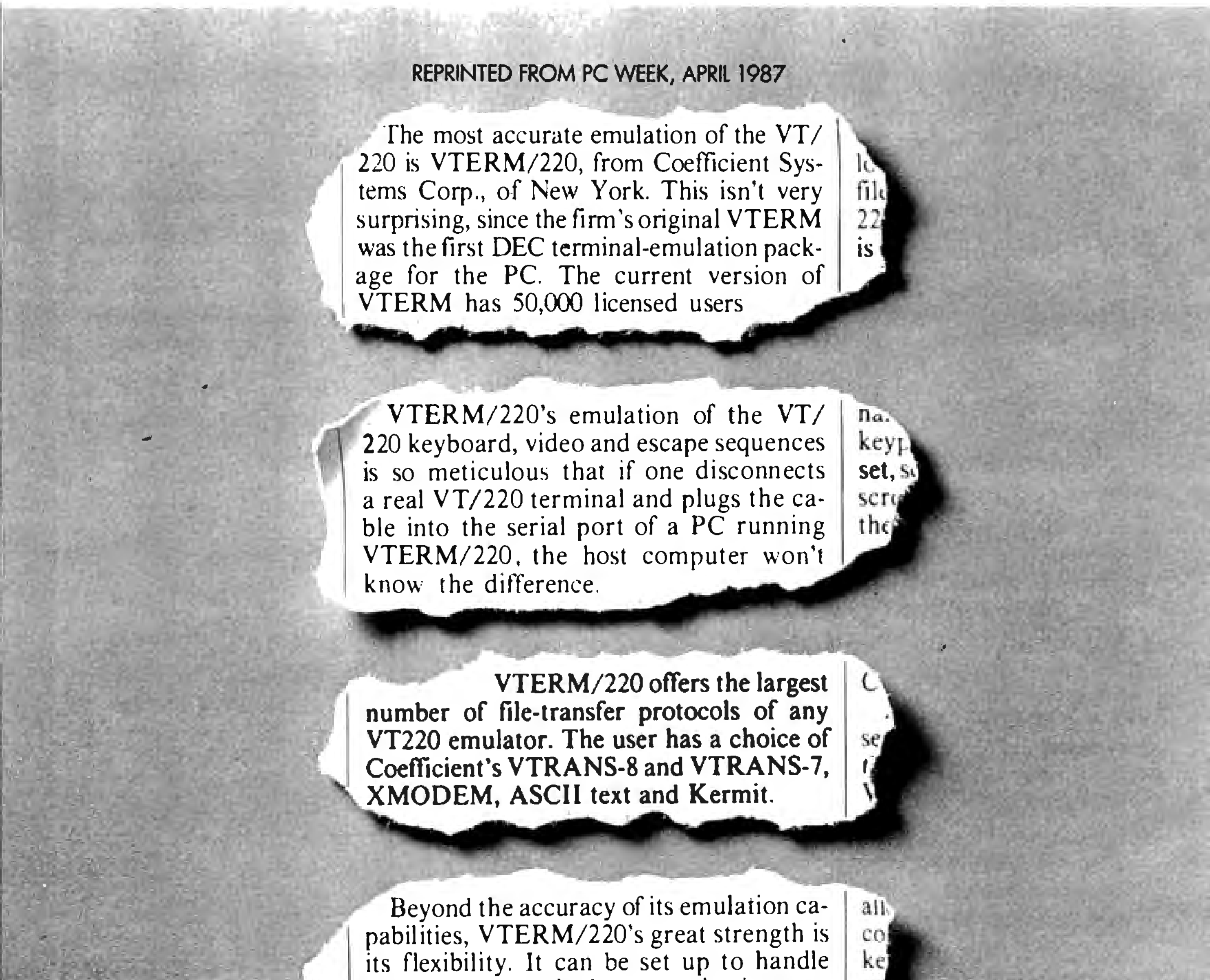
REPRINTED FROM PC WEEK, APRIL 1987

The most accurate emulation of the VT/220 is VTERM/220, from Coefficient Systems Corp., of New York. This isn't very surprising, since the firm's original VTERM was the first DEC terminal-emulation package for the PC. The current version of VTERM has 50,000 licensed users

VTERM/220's emulation of the VT/220 keyboard, video and escape sequences is so meticulous that if one disconnects a real VT/220 terminal and plugs the cable into the serial port of a PC running VTERM/220, the host computer won't know the difference.

VTERM/220 offers the largest number of file-transfer protocols of any VT220 emulator. The user has a choice of Coefficient's VTRANS-8 and VTRANS-7, XMODEM, ASCII text and Kermit.

Beyond the accuracy of its emulation capabilities, VTERM/220's great strength is its flexibility. It can be set up to handle almost any terminal-communications requirement.

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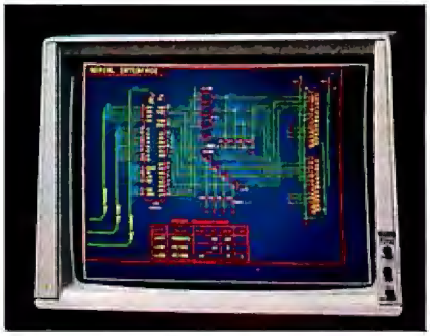

Convac displays up to 1024 by 1024.

New Monitors, More Features

Several high-quality color monitors for both old- and new-generation video boards have been recently introduced. Here are three of the most interesting.

NEC Home Electronics has two new color monitors, both similar to the company's popular 13-inch MultiSync monitor. NEC claims the monitors are compatible with all modes of the new VGA graphics adapter on the IBM PS/2 computers, as well as with all previous IBM PC graphics adapters, such as CGA, EGA, and PGA.

The new MultiSync Plus measures 15 inches diagonally and has a maximum resolution of 960 by 720 pixels. The MultiSync XL measures 20 inches diagonally and has a maximum resolution of 1024 by 768 pixels.

Both monitors have a standard 9-pin connector and a 4-pin BNC connector. NEC also has a small adapter that lets you attach the 9-pin connector to the 15-pin cable used by the new IBM PS/2 computers.

Price: MultiSync Plus, $1399; MultiSync XL, $3195.
Contact: NEC Home Electronics Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
Inquiry 576.

Zenith's 14-inch ZCM-1490 Flat Technology Monitor is, as the name implies, a color computer monitor with a perfectly flat screen surface. The monitor uses the flat tension-mask tube technology developed, patented, and manufactured by Zenith. According to the company, advantages of the flat screen include at least 50 percent increased brightness, 70 percent greater contrast, 95 percent reduced glare, and greater character and color definition.

The monitor is designed to support the high-resolution video output generated by PS/2 computers and comparable video cards such as the Zenith Z-449. It will also support CGA, MDA, Hercules, EGA, and PGA modes. The unit's horizontal scan frequency is 31.5 kHz, and dot pitch is 0.31mm.

The ZCM-1490 includes a PS/2-compatible 15-pin cable connector. The unit weighs about 40 pounds.

Price: $999.
Contact: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025, (312) 699-4839.
Inquiry 577.

Conrac, a manufacturer long known for its high-end studio broadcast monitors, is offering the 7250, a 19-inch multiscanning monitor. The company claims that the unit is compatible with all popular graphics cards and all video modes with a resolution of up to 1024 by 1024 pixels interlaced at scan rates of from 15.75 kHz to 37 kHz.

The 7250 uses a high-contrast, antiglare precision in-line CRT with a dot pitch of 0.31mm. The 7250 also offers auto-switching between 40-MHz analog and 16/64-color TTL, as well as automatic internal/external sync select.

Price: $2995.
Contact: Conrac, 600 North Rimsdale Ave., Covina, CA 91722, (818) 966-3511.
Inquiry 578.

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Prolog Compiler

The Cogent Prolog Compiler offers a full implementation of the standard Edinburgh Prolog language with over 150 predefined procedures. It provides support for real, string, and database reference types. The development environment includes the Prolog Compiler and Interpreter, as well as a window-based debugger, a help subsystem, and a dynamic loader. The compiler also offers user-programmable windowing, screen control, and error trapping and handling.

Sample Prolog expert-system, language-processing, and decision-support programs are included. It also includes a run-time version, which requires an IBM PC or compatible with at least 256K bytes of RAM. To run the compiler, you need 384K bytes of RAM.

Price: $200.
Contact: Cogent Software Ltd., 21 William J. Heights, Framingham, MA 01701, (617) 875-6553.
Inquiry 579.

continued

Professional Drawings with Windows

Instinct Plus, a technical drawing program, runs in the Microsoft Windows environment. Cadlogic reports that Instinct Plus is the advanced version of Instinct and operates with the same interface.

Enhancements in Instinct include multiple drawing windows and views that you can work in simultaneously, enhanced text-handling and bit-map capabilities, 512 colors to choose from, additional pattern textures, added graphics commands, and eight levels of Undo. Symbol handling is also enhanced in Instinct Plus, offering you the capability of naming individual symbols.

The program requires Microsoft Windows and runs on IBM PCs, XTs, ATs, or compatibles with at least 320K bytes of RAM. Cadlogic recommends 512K with a hard disk drive. You also need an EGA, Hercules Graphics Card, or other Windows-compatible device, and a mouse or other Windows-compatible input device. Word processors supported include Windows Write, Microsoft Word, ASCII Text Files, and others. It also supports Windows Paint and Aldus PageMaker.
Price: Under $300.
Contact: Cadlogic Systems Corp., 2635 North First St., Suite 202, San Jose, CA 95134, (408) 943-9696.
Inquiry 580.

Run IBM Software on the Atari

PC-Ditto, an emulation program from Avant-Garde Systems, enables an Atari 520ST or 1040ST to run IBM software, including Lotus 1-2-3 and Flight Simulator.

The program features up to 703K bytes of usable memory (on the 1040ST), monochrome and color graphics capabilities, serial- and parallel-port emulation, and support of 3½-inch 80-track drives and optional 5¼-inch 40-track drives.
Price: $89.95.
Contact: Avant-Garde Systems, 381 Pablo Point Dr., Jacksonville, FL 32225, (904) 221-2904.
Inquiry 581.

Instinct Plus, an enhanced version of Instinct.

PC-Based Background Voice Mail

Although the CAM (complete answering machine) is not the first voice-mail card for PCs, it is the first to operate in the background so that the computer answers the phone even while you're using your system for other things. The three-quarter-length CAM board, available from The Complete PC, uses proprietary circuitry to digitize human speech and proprietary compression algorithms to store them on a hard disk. A 5-minute message takes about 1 megabyte of storage space on the disk, or about 3 to 3½K bytes of disk storage for each second of speech.

The CAM system enables several people to have private, password-protected voice mailboxes and personal greetings for each mailbox. Additionally, frequent callers can be assigned their own mailboxes, and confidential messages left for them. As messages are read, it is possible to forward them to other mailboxes, and users can listen to their messages, record outgoing messages, record new personal greetings, or change CAM parameters from a remote Touch-Tone phone.

The system requires DOS 2.1 or higher, a hard disk, 384K bytes of RAM, a standard Touch-Tone telephone, and a Touch-Tone telephone line. An external speaker, which plugs into the card, is also recommended.
Price: $349.
Contact: The Complete PC, 521 Cottonwood Dr., Milpitas, CA 95035, (408) 434-0145.
Inquiry 582.

Sharp's Newest Portable ATs

Sharp Electronics Corporation has a new family of AT-class portable machines. The 80286-based portables, which are part of the new PC-7200 family of "compact personal computers," are available in two configurations. The PC-7202 has dual 5¼-inch floppy disk drives, and the PC-7221 has a single 5¼-inch floppy disk drive and a 20-megabyte hard disk drive. Both units use supertwist liquid-crystal backlit displays with 640- by 200-pixel resolution and four levels of gray scale. In addition, the units have PC AT-style keyboards and Phoenix BIOS. Both weigh approximately 21 pounds and come with 640K bytes of RAM, expandable to 1.6 megabytes on the system board.

A full-size expansion slot is built into the side of the machine. To insert a card, you remove a small panel from the side of the PC and slide the end of the card into the slot, much the way you insert a disk. Both systems run at 6, 8, and 10 MHz and include serial, parallel, and CGA/MDA video ports.
Price: 7202, $2995; 7221, $3995.
Contact: Sharp Electronics Corp., Sharp Plaza, Mahwah, NJ 07430, (201) 529-9500.
Inquiry 583.

LX-800 Fast and Inexpensive

Epson's LX-800 printer, a 9-pin, 80-column dot-matrix model, is the company's lowest-priced printer. Epson claims the unit prints at 180 characters per second in elite draft mode and 30 cps in near-letter-quality mode.

Standard features include a built-in pull-type tractor feed, a 3K-byte buffer, automatic single-sheet loading, a parallel interface, and a one-year warranty. Also included is a SelecType front panel that lets you select fonts, type styles, and pitches without having to change DIP switches. The LX-800 comes with both roman and sans serif near-letter-quality fonts installed.

The LX-800 measures 3.6 by 15.7 by 12.1 inches and weighs 11.02 pounds. Available options are 32K-byte serial and parallel buffered interfaces.
Price: $269.
Contact: Epson America Inc., 2780 Lomita Blvd., Torrance, CA 90505, (213) 539-9140.
Inquiry 584.

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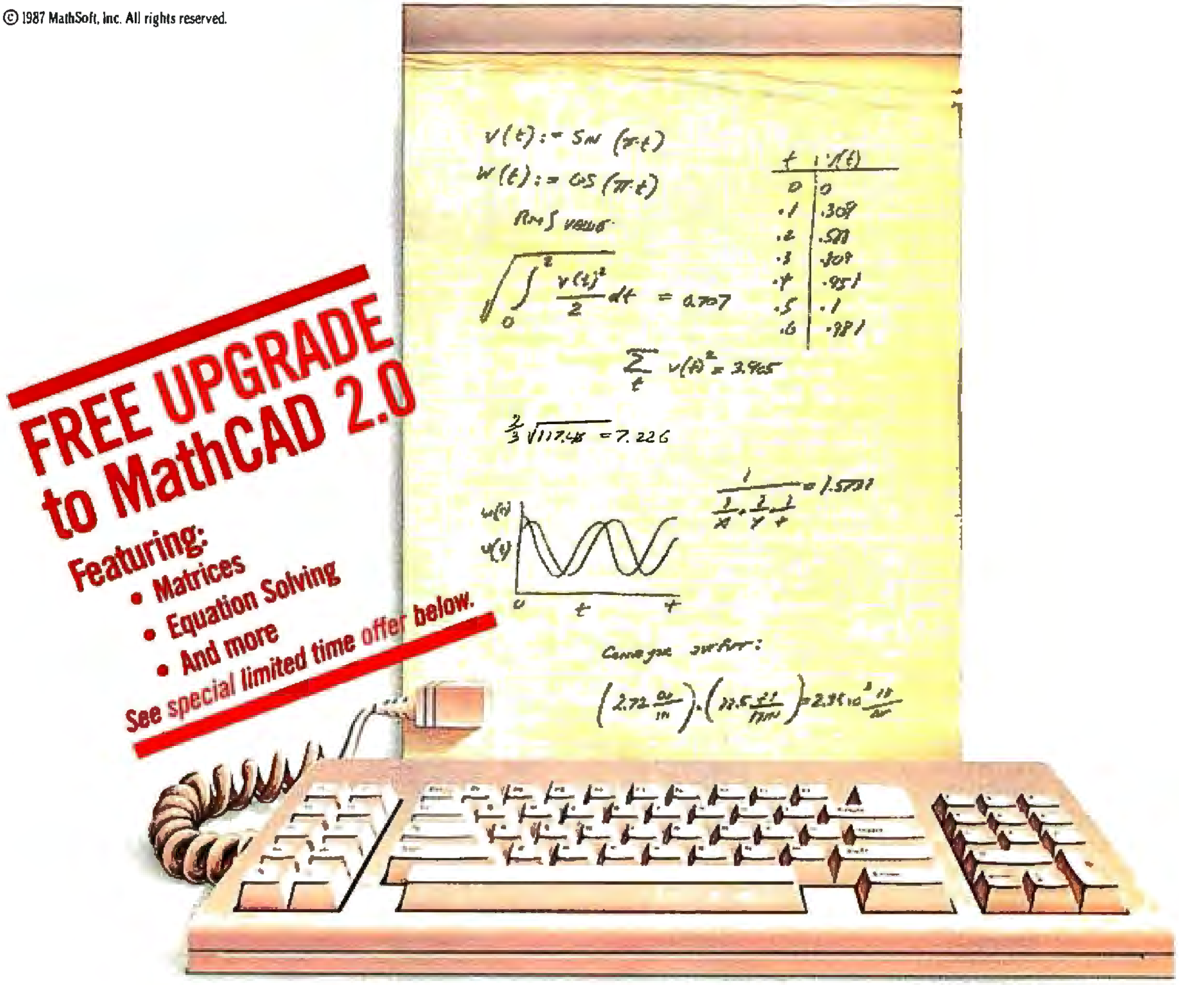

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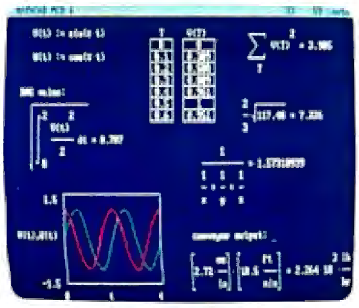

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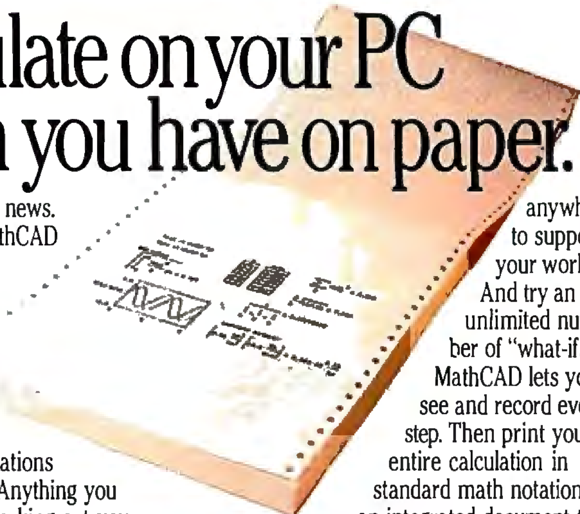

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Microsoft Mouse for the PS/2

Microsoft's ubiquitous two-button mechanical mouse is now available for the IBM PS/2 series pointing-device port. New driver software is included that supports the advanced video capabilities of the new machines—CGA Superset Graphics on the Model 30 and EGA Superset Graphics on Models 50 and 60.

The mouse is packaged with upgraded versions of both Show Partner and Microsoft Paintbrush. Both programs are designed to take advantage of the new video capabilities of the PS/2 systems.

To use the PS/2 version of the Microsoft Mouse, you'll need at least one 3½-inch disk drive, DOS 3.3 or higher, and a PS/2 pointing-device port. No external power supply is needed since the mouse gets its power from the pointing-device port.

Price: $175.

Contact: Microsoft Customer Service, 16011 Northeast 36th Way, P.O. Box 97017, Redmond, WA 98073, (800) 426-9400; (206) 882-8088 in WA and Alaska.

Inquiry 585.

New Microsoft mouse works with the PS/2.

Webster's On-Line

Proximity Technology, known for its spelling checkers bundled in electronic typewriters and other software products, announced Webster's Collegiate Thesaurus, an electronic reprint of the book. It provides 40,000 entry points, 470,000 synonym responses (stored rather than rule-based), meanings, inflection, and spelling correction. The thesaurus also lets you place the synonym automatically in your text.

It runs on IBM PCs, XTs, or compatibles with MS-DOS 2.0 or higher and on IBM PC ATs with MS-DOS 3.0 or higher. You also need two floppy disk drives, an 80-column color or monochrome display, and 80K bytes of free system memory.

Proximity also announced Webster's Electronic Dictionary, based on Merriam-Webster's *Vest Pocket Dictionary*. It contains 80,000 words with dictionary definitions, provides hyphenation points, and corrects spelling errors. The dictionary should be available this month or in September.

The dictionary will also run on IBM PCs and compatibles and will require 80K bytes of free memory.

The third Proximity announcement is Friendly Finder, a dBASE search utility that performs what Proximity calls "fuzzy" searches, providing you with up to 16 close matches each time you search. The search utility also has the capability of integrating the fields you find into other applications.

Proximity also announced that these three products will fit in a total of 80K bytes in your system, rather than using 80K for each.

Price: Webster's Collegiate Thesaurus, $89.95; Webster's Electronic Dictionary, $89.95 or $129.95 with Thesaurus; Friendly Finder, $89.95.

Contact: Proximity Technology Inc., 3511 Northeast 22nd Ave., Fort Lauderdale, FL 33308, (305) 566-3511.

Inquiry 586.

XyWrite III Plus

Some of the added features in the most recent XyWrite release include a spelling checker, thesaurus, and text-redlining and word-counting capabilities.

The spelling checker contains a 100,000-word dictionary and a personal dictionary to which you can add up to 10,000 specialized or technical terms. You can also check for errors by word, phrase, line, file, or list of files. In the optional Auto-check/Correct mode, typos are spotted as you make them. And finally, the shorthand feature lets you type a phrase such as ASAP and get the full phrase "as soon as possible" in return.

The thesaurus is Microlytics' Word Finder. It provides 220,000 synonyms for 15,000 key words and features hidden notes, word counting, and the ability to embed printer control codes in documents.

XyWrite III Plus runs on IBM PCs and compatibles with at least 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher.

Price: $445.

Contact: Xyquest, 3 Loomis St., Bedford, MA 01730, (617) 275-4439.

Inquiry 587.

PC-to-Anything Communications

PC Blast II is a proprietary-protocol communications program that includes a new Lotus-type menu interface and context-sensitive help. It is designed primarily to communicate with other systems running Blast; and Communication Research Group has versions of the software that run under 31 different operating systems, which include CP/M, Unix, numerous minicomputer operating systems, and both IBM and Amdahl mainframe operating systems.

The current version is the fourth major upgrade since the package was introduced in 1981. PC Blast II is intelligent enough to sense whether the remote system is using Blast and, if so, which version. It then looks at line quality, and the two sides agree on transmission speed. The company claims that file transfer using the newest Blast protocol with a 1200-bit-per-second modem is equivalent to "well over 2400 bps."

You can also use PC Blast II as a standard communications package when connected to non-Blast-equipped remote systems. It provides, among others, ANSI, VT-52, and VT-100 terminal emulation and can use both ASCII and 8-bit Xmodem transfers.

PC Blast II also includes an extensive scripting language. You can prepare scripts using any ASCII editor, and sample scripts are included.

Price: $250; Blast II for Unix and Xenix systems, $395.

Contact: Communications Research Group, 5615 Corporate Blvd., Baton Rouge, LA 70808, (504) 923-0888.

Inquiry 588.

continued

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DMM-200 $49.95

3.5 DIGIT FULL FUNCTION DMM

High accuracy, 20 amp current capability and many range settings make this model ideal for serious bench or field work. Tilt stand for hands-free operation. 2000 hour battery life with standard 9v cell. Probes and battery included.

* Basic DC accuracy: plus or minus 0.25%
* DC voltage: 200mv — 1000v, 5 ranges
* AC voltage: 200mv — 750v, 5 ranges
* Resistance: 200 ohms — 20M ohms, 6 ranges
* AC/DC current: 200uA — 20A, 6 ranges
* Fully over-load protected
* Input impedance: 10M ohm
* 180 x 86 x 37mm, weighs 320 grams

DMM-700 $49.95

3.5 DIGIT AUTORANGING DMM

Autorange convenience or fully manual operation. Selectable LO OHM mode permits accurate in-circuit resistance measurements involving semi-conductor junctions. MEM mode for measurements relative to a specific reading. Probes and battery included.

* Basic DC accuracy: plus or minus 0.5%
* DC voltage: 200mv — 1000v, autoranging or 5 manual ranges
* AC voltage: 2v — 750v, autoranging or 4 manual ranges
* Resistance: 200 ohms — 20M ohms, autoranging
* AC/DC current: 20mA — 10A, 2 ranges
* Fully over-load protected
* Audible continuity tester
* Input impedance: 10M ohm
* 150 x 75 x 34mm, weighs 230 grams

DMM-100 $29.95

3.5 DIGIT POCKET SIZE DMM

Shirt-pocket portability with no compromise in features or accuracy. Large, easy to read .5" LCD display. 2000 hour battery life with standard 9v cell provides over two years of average use. Probes and battery included.

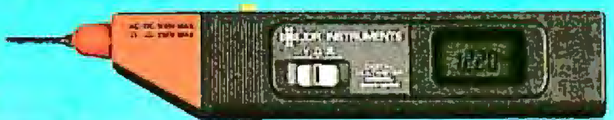
* Basic DC accuracy: plus or minus 0.5%
* DC voltage: 2v — 1000v, 4 ranges
* AC voltage: 200v — 750v, 2 ranges
* Resistance: 2k ohms — 2M ohms, 4 ranges
* DC current: 2mA — 2A, 4 ranges
* Fully over-load protected
* Input impedance: 10M ohm
* 130 x 75 x 28mm, weighs 195 grams

MODEL 2000 $349.95

20 MHz DUAL TRACE OSCILLOSCOPE

Model 2000 combines useful features and exacting quality. Frequency calculation and phase measurement are quick and easy in the X-Y Mode. Service technicians will appreciate the TV Sync circuitry for viewing TV-V and TV-H as well as accurate synchronization of the Video Signal, Blanking Pedestals, VITS and Verticle/Horizontal sync pulses.

* Lab quality compensated 10X probes included
* Built-in component tester
* 110/220 Volt operation
* X-Y operation * Bright 5" CRT * TV Sync filter



DPM-1000 $54.95

3.5 DIGIT PROBE TYPE DMM

Autoranging, pen style design for the ultimate in portability and ease of use. Custom 80 pin LSI chip increases reliability. Audible continuity tester and data hold feature for added convenience. Case, test leads and batteries included.

* Basic DC accuracy: plus or minus 1%
* DC voltage: 2v — 500v, autoranging
* AC voltage: 2v — 500v, autoranging
* Resistance: 2k ohms — 2M ohms, autoranging
* Fully over-load protected
* Input impedance: 11M ohm
* 162 x 28 x 17mm, weighs 75 grams

MODEL 3500 $499.95

35 MHz DUAL TRACE OSCILLOSCOPE

Wide bandwidth and exceptional 1mV/DIV sensitivity make the Model 3500 a powerful diagnostic tool for engineers or technicians. Delayed triggering allows any portion of a waveform to be isolated and expanded for closer inspection. Variable Holdoff makes possible the stable viewing of complex waveforms.

* Lab quality compensated 10X probes included
* Delayed and single sweep modes
* Z Axis intensity modulation
* X-Y operation * Bright 5" CRT * TV Sync filter

2 YEAR WARRANTY ON ALL MODELS

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SAN JOSE, CA. (408) 947-8881

Inquiry 128

The PC Upgrade Path

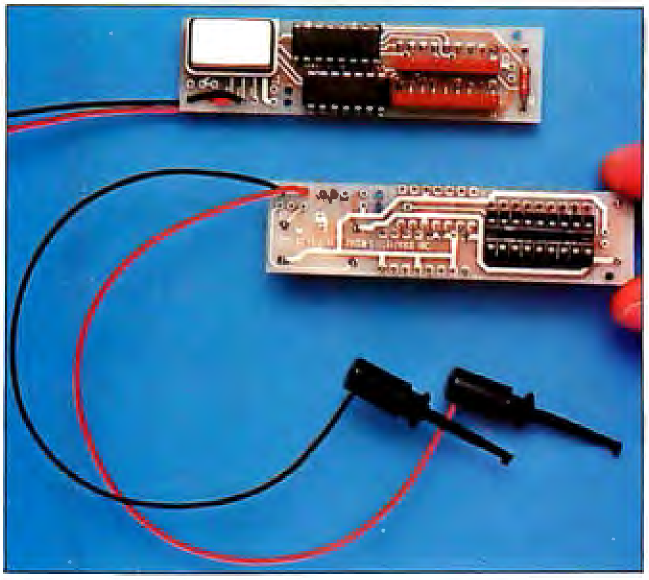
With all the hoopla about the new PS/2 machines, you might think that the original IBM PCs had been long relegated to junkyards or dusty corners, but products continue to be introduced for the original IBM workhorse. Here are two.

Addcard is a low-cost unit that adds four half-length expansion slots to the five available in the original IBM PC. Since Addcard uses one of the five slots, there are eight cards after adding Addcard, four full-length and four half-length.

The new expansion slots let you mount half-length cards horizontally (parallel to the motherboard). The cards occupy the empty space behind the left floppy disk drive and next to the power supply.
Price: $79.
Contact: Merak Industries, 8704 Edna St., Warren, MI 48093, (800) 231-4310; in Michigan, (313) 562-9768.
Inquiry 589.

Meanwhile, Prism Electronics has started shipping the PC-Bandit, an accelerator circuit card for the IBM PC, XT, and compatibles that runs at a clock speed of 4.77 MHz only. The PC-Bandit doesn't require an expansion slot. Instead, it fits into the socket of the system's current 8284 clock chip. The only additional steps needed for installation are to connect two wires: one to the DMA chip, the other to the motherboard for software-selectable speed changing.

Two versions of PC-Bandit are available. One, for systems with 150-nanosecond memory chips, increases system speed to 7.4 MHz; the other, for older systems with 200-ns memory chips, increases system speed to 6.7 MHz.
Price: $69.95.
Contact: Prism Electronics, 14682 Northeast 95th St., Redmond, WA 98052, (206) 881-1088.
Inquiry 590.



The PC-Bandit upgrades 4.77-MHz PC systems.

WordPerfect for Laptops, Amigas, Ataris, and Macs

WordPerfect Executive, designed for laptops, combines a spreadsheet, word processor, and a group of management utilities, such as a calendar, notebook, and calculator.

Executive uses the shell of WordPerfect's Library, although some minor changes have been made to the calendar, which now archives the dates after 21 days rather than 7. The calculator, on the other hand, is changed substantially. Library's Notebook is changed to a run-time version with two parts: one for keeping notes and the other for names and addresses.

Executive's spreadsheet is a subset of WordPerfect's previous version. Text graphics are kept; bit-mapped graphics are removed.

The word-processing function is also similar to WordPerfect, with the spelling function left in and the thesaurus removed.

The company reports that you can have all modules resident on a 640K-byte machine. It requires an IBM PC or compatible with at least 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and it comes on both 3½- and 5¼-inch disks.

WordPerfect also announced plans to ship a version of WordPerfect for the Amiga, and Macintosh and Atari ST versions will follow.
Price: WordPerfect Executive, $249; WordPerfect for the Amiga and the Atari, $395 each.
Contact: WordPerfect Corp., 266 West Center, Orem, UT 84057, (801) 227-4010.
Inquiry 591.

Transportable Hard Disk

Best known for its hard disk drives and other peripherals designed for DEC VAXmate systems, dmi now has a 20-megabyte portable hard disk system designed for all PC ATs and compatibles. Unlike Tandon's recently introduced Personal Data Pacs, which require Ad Pac "mother units" for plugging in the Pacs, dmi's units simply plug into the back of the computer system.

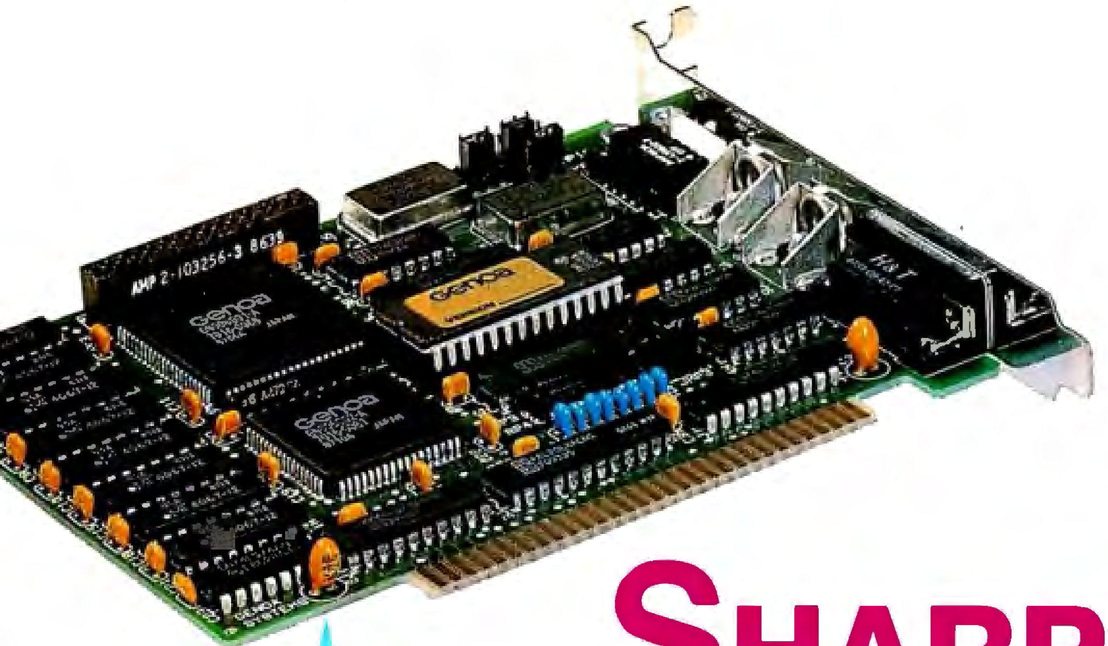
The dmi microPortable Disk System is a shock-mounted 3½-inch hard disk drive that's housed in a case that measures 1.5 by 4 by 5.75 inches. You can connect the unit to the AT's hard disk controller using a special cabling kit that also provides power to the drive via a parallel connector on the rear of the microPortable. The unit weighs about 2 pounds and has an average access time of 65 ms.

For installations where security is needed, the disk unit has a key lock on the rear of the case that disconnects the drive-select line. The drive can also be unplugged and carried away in just a few seconds. The drive heads automatically park on power-down, and the company claims the disks can take up to a 60-g shock without damage.
Price: $1095.
Contact: dmi, 27635 Forbes Rd., Suite H, Laguna Niguel, CA 92677, (714) 955-2422.
Inquiry 592.

80387 Available Now

Intel Corporation's end-user version of its 80387 math coprocessor has a clock speed of 16 MHz. The 80387 has been optimized for the 80386 to provide the highest possible floating-point performance. It directly extends the 80386 instruction set to include trigonometric, logarithmic, exponential, and arithmetic instructions.

The 80387's object code is directly compatible with 8087 and 80287 math coprocessors, so it can be used immediately with a large variety of software, including Lotus 1-2-3 and Symphony, Autodesk's AutoCAD, Ansa's Paradox, Borland's Turbo Pascal, and Javelin.
Price: $795.
Contact: Intel Corp., 5200 Northeast Elam Young Parkway, Hillsboro, OR 97124, (503) 629-7354.
Inquiry 593.



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SYSTEMS

TI's Multiuser 80386

The System 1300 from Texas Instruments is based on the 80386 and will support up to 32 users. TI claims it's the first 80386 system to use error-correcting-code (ECC) memory for high reliability. The basic System 1300 comes with 4 megabytes of high-speed RAM that can be expanded to 16 megabytes. Included are 16K bytes of cache memory, and mass storage can be expanded up to 2.1 gigabytes. Sixteen terminal ports are standard.

The System 1300 uses the TI System V operating environment, based on Xenix System 5 from Microsoft. A SCSI port is standard. TI offers two base models of the 1300: The Model 1325 has 182 megabytes of hard disk storage, and the Model 1350 has 364 megabytes of storage. A 60-megabyte cartridge-tape backup unit is standard with both.
Price: Starts at $27,495.
Contact: Texas Instruments Inc., Data Systems Group, P.O. Box 809063, DSG-123, Dallas, TX 75380, (800) 527-3500.
Inquiry 594.

TI's System 1300: 32 users on an 80386.

More Toshiba Laptops

The T1000, Toshiba's new 80C88-based laptop computer, weighs 6.4 pounds. It comes with a single 720K-byte 3½-inch disk drive, 512K bytes of RAM (with a card you can give it 128K bytes more and 640K bytes of Lotus/Intel/Microsoft expanded memory), and an 80 by 25 supertwist LCD. MS-DOS 2.1 is in ROM. There are six ports: parallel, serial, RGB color video, composite video, 5¼-inch drive, and external numeric pad. Internal space is also available for a modem.

Toshiba is also offering its new T1200, which is similar to the T1100 Plus but has a 20-megabyte hard disk drive (78-ms access time). The T1200 uses an 80C86 that runs at 4.77 or 9.54 MHz. It weighs 10.8 pounds and has a supertwist display, a 720K-byte 3½-inch disk drive, MS-DOS 3.2, and 640K bytes of user memory along with 384K bytes of LIM EMS memory. SideKick is also included. Options include an expansion chassis with five slots and an external 5¼-inch disk drive.
Price: T1000, $1199; T1200, price not yet available.
Contact: Toshiba America Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718, (714) 380-3000.
Inquiry 595.

One EaZy PC

Zenith's eaZy pc is a low-cost, small but complete PC-compatible hardware/software system with a Macintosh-like interface. The company claims it can be up and running within 5 minutes of being unpacked. The operating system interface, called MS-DOS Manager, was designed by Microsoft and uses windows and drop-down menus. The eaZy pc is an "all-in-one" design, with a black-and-white monochrome screen that is permanently attached to the system unit with a base that allows the screen to tilt and swivel. The 14-inch screen uses a black-on-white display, like the Macintosh. It uses the same type of double-scan CGA as the IBM PS/2 Model 30, which results in a resolution of 400 lines.

The eaZy pc is designed with 3½-inch disk drives. It has a footprint of slightly over 1 square foot. The machine uses an NEC V-40 microprocessor, has a clock speed of 7.14 MHz with zero wait states, and has 512K bytes of RAM. A mouse port and a parallel printer port are standard. There are no expansion slots, but add-on cartridges will be available. Upgrades will include memory, internal modems, and a serial port.

The system is available in three configurations. The Model 1 has a single 3½-inch disk drive; the Model 2 has two 3½-inch drives; and the Model 20 has a single 3½-inch drive and an internal 20-megabyte hard disk.
Price: Model 1, $999; Model 2, $1199; Model 20, $1699.
Contact: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025, (800) 842-9000, extension 1.
Inquiry 596.

HP's 68020 Workstation

The 318M from Hewlett-Packard is a monochromatic workstation based on a Motorola 68020 processor running at 16.6 MHz. A 68881 floating-point arithmetic coprocessor is standard, as is 4 megabytes of high-speed RAM using 1-megabit chips and Motorola's paged memory-management unit.

The system comes with a 17-inch monochrome display with a resolution of 1024 by 768. Standard interfaces include the HP-IB (IEEE-488) with DMA, RS-232C, ThinLAN (IEEE 802.3/Ethernet), and HP-HIL (human interface loop).

The 318M uses the HP-UX operating system, which is compatible with the Unix System V interface definition. The base model has a single built-in 3½-inch floppy disk drive. The system is also available with an 80-megabyte hard disk drive and a 60-megabyte tape backup unit.
Price: $7800; with 80-megabyte hard disk drive and 60-megabyte tape backup, $14,550.
Contact: Hewlett-Packard, 1820 Embarcadero Rd., Palo Alto, CA 94304, (415) 857-1501, or call the nearest HP sales office listed in the white pages.
Inquiry 597.

continued

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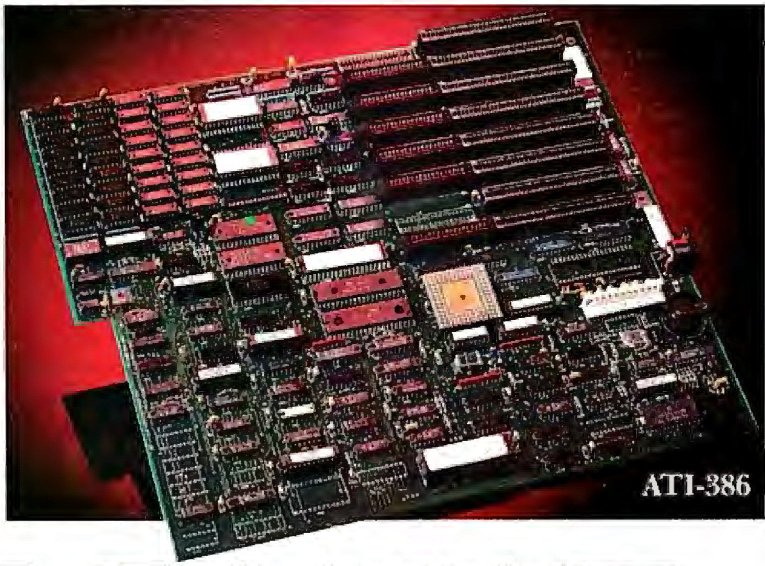

ADVANCE TO THE NEXT LEVEL

ATI-386

The ATI-386 AT board is a high-performance system board that provides the primary elements for building advanced personal computers. The board is functionally compatible with the system board in the IBM AT. However, it contains an 80386 microprocessor, 32-bit access to data and other features that give it over twice the performance of an 8MHz IBM AT.

Other features include downward compatibility with IBM 8 MHz AT, one MByte 32-bit on-board memory expandable to 16 MByte, a socket for the Intel 80387 math co-processor and more.

ATI-386-64

The ATI-386/64 Board features the same specifications as the ATI-386 AT board as well as on-board 64 KByte cache memory, cacheable to a full 16 MByte memory space to achieve nearly zero-wait state operation at full speed.

ATI-6/12 System 286

The ATI System 286-12 runs at an amazing speed of 12MHz. That's 20% faster than the IBM* Personal System 2 50/60.

And to protect your existing investment, we've built-in a normal-speed mode as well. A few simple keystrokes will switch you to 6MHz operation mode, when necessary.

Combine the ATI System 286-12 with our MegaGraph Plus EGA board to get superb graphics performance. Or expand your system's main memory with the ATI Multifunction card. Expand from single-user to multi-user system with up to five disk drive slots and eight expansion slots. 6/8 & 6/10 MHz systems also available.

12 MHz Multifunction Card

Our versatile multifunction card features a system bus of 12MHz. Sockets on board to handle up to 2.5 MBytes of memory, one serial port, one parallel port, one game port. Optional second serial port available.

Professional Image Board

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 PC/XT/AT personal computers or IBM compatibles. Now, live, fast action scenes can be instantly captured in full color and frozen. The frozen pictures can be stored on a floppy or hard disk. The frozen pictures can also be transmitted to any remote computer in the world via modem or network.

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Texas contact: **ATronics** 14900 Landmark Blvd., Suite 411, Dallas, TX 75240 **(214) 980-2518 FAX: (214) 490-6525.**

PERIPHERALS

High-Quality Slides from Data

The ModelViewer Series DI-300 is a digital image recording system that outputs computer-generated designs to 35mm slides or instant color prints. The unit can process up to 24 bits of color information, producing up to 16.7 million simultaneous colors.

The unit connects directly to engineering workstations, computer systems, and networks and operates independently of video RGB signals. ModelViewer software resides on the computer and runs with DEC, Sun, Apollo, and IBM PC systems. A general-purpose software driver kit is available for interfacing the ModelViewer to proprietary or custom software environments.

The software processes an image file that can be either bit-mapped or vector data. The unit connects to the system's RS-232C serial port. Color photographs are generated by sequentially exposing the red, green, and blue components of an image. Exposure is controlled by a time-based algorithm.

The ModelViewer system includes a high-resolution film recorder, a graphics processor, a software interface, a 35mm camera back, and an instant print camera back.

Price: $9000.

Contact: Data Innovations, 323 New Boston St., Wilmington, MA 01887, (617) 933-8170.

Inquiry 598.

A 35mm slide from the DI-300 digital image recording system.

New ThunderScan Can Produce Halftones

Thunderware has introduced an enhanced version of its ThunderScan high-resolution optical digitizer for all models of the Macintosh. The unit, which fits into the Apple Imagewriter in place of the printer ribbon, now produces true PostScript-compatible halftones. With a halftone image, unlike a bit-mapped image, you can modify the contrast and brightness. Software included with ThunderScan also lets you add captions and produce special effects such as framing, image shaping, rotation, inversion, and line screens.

Other new features include support of multiple file formats, including Encapsulated PostScript (EPSF), Draw format (PICT), Tag Image File Format (TIFF), MacPaint (PNTG), and ThunderScan's own file format (SCAN). Also new are a lasso tool for selecting irregularly shaped areas, support of a larger clipboard for the Macintosh SE and Plus, and a what-you-see-is-what-you-get option.

ThunderScan now comes packed with Power Port, which makes the unit compatible with the Mac Plus and SE. Power Port connects to the Plus or SE's external disk drive port and provides one connector for the disk drive and another for ThunderScan or another peripheral. You can also connect ThunderScan to a Macintosh II with an optional adapter. It can connect directly to a Macintosh with 128K or 512K bytes.

Price: $249; Mac II adapter, $49.

Contact: Thunderware Inc., 21 Orinda Way, Orinda, CA 94563, (415) 254-6581.

Inquiry 599.

High-Performance Mac Keyboards

The MAC-101 and MAC-101/ADB are full-function keyboards for the Macintosh that are similar in design to the 101-key enhanced keyboard for IBM PCs and compatibles. The MAC-101 is designed for all models of the Macintosh from the 128 on up, while the MAC-101/ADB takes advantage of the new features of the Macintosh SE and Macintosh II. The MAC-101/ADB has built-in Apple Desktop Bus connectors, which allow daisy-chaining of up to 16 input devices, including mouse, graphics tablet, and joystick.

Both keyboards have 15 user-definable function keys and come with a keyboard enhancement program called 101-KEYS that installs as a desk accessory and lets you assign macros to the function keys. A predefined 101-KEYS macro file is included for Microsoft Word 3.

Price: $169.95.

Contact: DataDesk International, 7650 Haskell Ave., Van Nuys, CA 91406, (818) 780-1673.

Inquiry 600.

24-pin Printer Does Color, Too

Fujitsu is offering a new series of low-cost 24-pin printers. The DL3300 is an 80-column unit, and the DL3400 prints up to 136 columns. Both offer three printing speeds: high-speed draft at 288 characters per second, regular draft at 216 cps, and letter-quality at 72 cps.

Courier 10, Prestige Elite, and Compressed fonts are standard. Other typefaces are available in optional font cards. All printer functions are selectable using front-panel switches, and frequently used settings can be stored in memory. The printers come with a standard Centronics parallel interface. An RS-232C interface is optional. You can easily upgrade both units to print in seven colors by using the optional color kit.

The printers emulate the IBM Proprinter XL, the IBM Graphics Printer, and the Diablo 630. Epson JX-80 codes are available for color printing.

Price: DL3300, $795; DL3400, $995; serial interface, $30; color kit, $100.

Contact: Fujitsu America Inc., 3055 Orchard Dr., San Jose, CA 95134, (408) 946-8777.

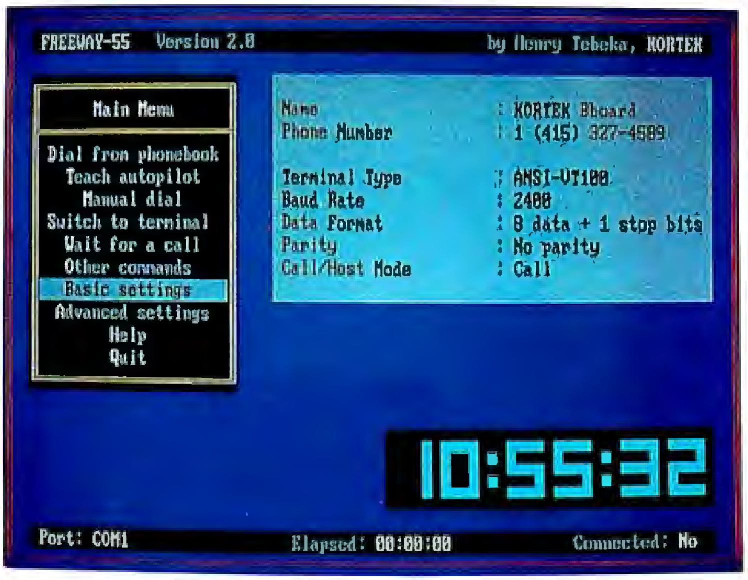
Inquiry 601.

continued

It's time you got on the Freeway !

The best communication software.

FREEWAY™

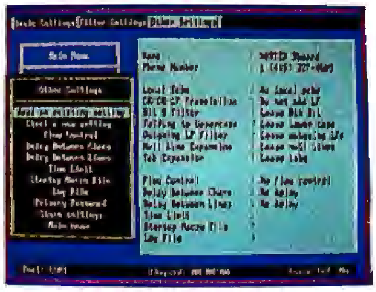


You don't have to get stuck in the potholes of computer communications.

You don't have to put up with the crooked lanes of obsolete communication software.

Not when you can get on the Freeway !

The most powerful



Just because Freeway is easy to use, doesn't mean it's weak. Freeway is communication software by and for the power user.

Automation: You shouldn't waste your time with simple chores. So Freeway automates your communication. It stores over 20 settings for each host you call in its Phonebook. If a number is busy, Freeway will redial until you get through. And, in addition to the Autopilot, Freeway includes a powerful script facility, with access to all Freeway's features. For instance, a script can wait until 2 a.m., call a BBS, check for mail, and download any new files, leaving you an exact transcript.

Control: Freeway gives you far more detailed control than just the usual baud rate and parity. You have seven filters for incoming and outgoing text. You can specify the characters used for flow control, and the length of a Break. In all, you have control of over 50 settings, most of which can be different for each phone number.

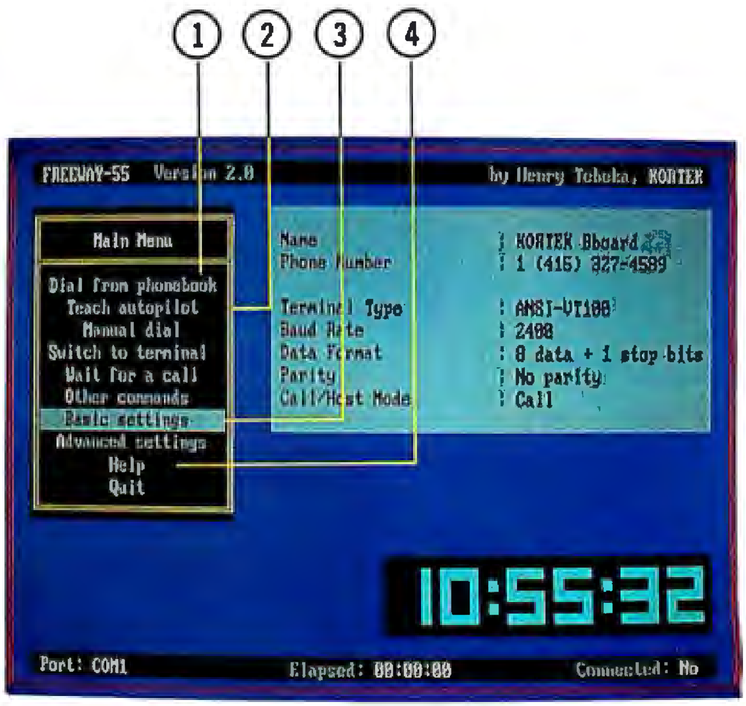
And remember, just because Freeway is powerful, doesn't mean it's difficult. The advanced features are as accessible as the basics, via fast menus with keyboard shortcuts.

FREEWAY™

is the best commu

The easiest to use

Take Freeway's simple menus and clear displays. Add the arrow keys and the Escape and Enter keys. The result is powerful but straightforward communication — at your fingertips.



(1) **Phonebooks:** Freeway lets you store the phone numbers (and other settings) for up to 100 computer systems. You just use the arrow keys to pick the number you want, hit Enter, and leave the dialing to us.

(2) **Autopilot:** Computer communication is more than just placing a call. You have to log on to the other computer, and often type introductory commands. Freeway provides an "autopilot" to relieve you of this chore. You simply go through these preliminaries once, with the autopilot noting your every move. Then, when you next call, the autopilot will do the work for you.

(3) **Setting Up:** Setting up Freeway is a piece of cake! The parameters you need — baud rate, parity, and even the number to call — are gathered in simple menus. To set them, you just zip through with arrows and Enter, and then save them in the Phonebook. Later, changing one or all of them is just as easy!

(4) **On-Line Help:** Even though Freeway is very easy to use, we all need a hint now and then. Every line of every menu has on-line help at the touch of a key.

ADD-INS

Elephant Has Large Memory

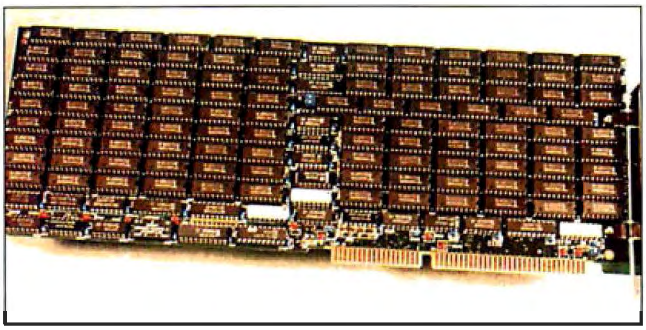
As the name implies, the Elephant-12 memory board from American Micronics can handle up to 12 megabytes of memory on a single-slot board for the IBM PC AT and compatibles. It will support up to 8 megabytes of EMS and 12 megabytes of IBM extended memory, or a combination of the two.

Using 100-nanosecond 1-megabit chips, the board will operate at up to 12 MHz with one wait state. The Elephant comes with intelligence that provides split-memory configuration without the need for setting DIP switches. The board is guaranteed for two years.

Price: $695 with 0K bytes; $6095 with 12 megabytes.

Contact: American Micronics Inc., 17831 Skypark Circle, Suite C, Irvine, CA 92714, (800) 443-6315; in California, (714) 261-2428.

Inquiry 602.



The Elephant packs up to 12 megabytes into a PC AT slot.

Graphics Board Has Two Coprocessors

Number Nine Computer Corporation's high-performance graphics card for IBM PCs and compatibles is based on both the Intel 82786 graphics coprocessor and the Texas Instruments TMS34010 graphics microprocessor. In the Pepper SGT, the Intel chip primarily handles display processing, performing functions such as horizontal line drawing at high speed, while the TI chip serves as a control processor, monitoring the activities of the Intel device. Additional functions performed by the Intel chip include hardware windowing and panning/scrolling; the TI chip handles rotation, scaling, and processing of downloaded custom algorithms.

One megabyte of video memory is standard, and the board also emulates CGA and MDA modes. EGA compatibility is optional. Without using special display drivers, the Pepper SGT replaces IBM text with a 16- by 19-color character cell array, some 300 percent sharper than standard EGA text.

Using variable scan monitors, you can display 640 by 480 resolution with up to 256 colors, or 16 colors can be shown at resolutions of either 800 by 600 or 1280 by 480. If you use an IBM monochrome monitor, resolution is 1280 by 350.

The Pepper SGT is compatible with numerous popular software packages, including Microsoft Windows, Lotus 1-2-3, Ventura Publisher, and AutoCAD.

Price: $995.

Contact: Number Nine Computer Corp., 725 Concord Ave., Cambridge, MA 02138, (617) 492-0999.

Inquiry 603.

20-MHz 80386 Motherboard for ATs

Computer Classifieds has a new 20-MHz 80386 replacement motherboard for the IBM PC AT and compatibles. Included on the motherboard are two 32-bit slots that can contain either 2 or 8 megabytes of RAM each (for a maximum of 16 megabytes), a floppy disk drive controller that supports both 5¼-inch and 3½-inch floppies, built-in EGA support, two serial ports, a parallel port, and sockets for both 80287 and 80386 coprocessors.

A ROM setup program for the motherboard lets you set parameters such as processor speed, DMA speed, and number of wait states upon boot-up.

Price: $4000.

Contact: Computer Classifieds Inc., 17830 State Rd. 9, Miami, FL 33162, (800) 331-5150.

Inquiry 604.

Standard Hard Disks in an Amiga

Amiga 1000 owners can connect up to four standard ST506/412 hard disk units to their systems by using the Phoenix Hard Disk Controller from RS Data Systems.

The board uses DMA in conjunction with on-board high-speed sector buffers to transfer data at the limit of the Amiga expansion bus (about 25 megabits per second). DMA transfers from the sector buffer occur in parallel with transfers from the hard disk.

The Phoenix will also support a 2-gigabyte laser disk, as well as a streaming-tape backup unit. It comes with its own power supply, cables, auto-configure backplane, expansion enclosure, and driver software. Designed to Zorro specifications, the Phoenix auto-configures under version 1.2 of AmigaDOS.

Price: $450; with 20-megabyte hard disk, $995.

Contact: RS Data Systems, 7322 Southwest Freeway, Suite 660, Houston, TX 77074, (713) 988-5441.

Inquiry 605.

Boost Your EGA with the Kicker

If you own an EGA card and a MultiSync or compatible monitor, Aristocad says its low-cost, plug-in enhancement board—named the Kicker—will boost resolution from 640 by 350 up to 800 by 560 or 800 by 600 with certain software.

The Kicker plugs into a standard EGA feature adapter and includes software drivers for GEM Desktop and Ventura Publisher (at 800 by 560) and AutoCAD (at 800 by 600). According to Aristocad, drivers will soon be available for Microsoft Windows and VersaCAD.

Price: $195.

Contact: Aristocad Inc., 333 Cobalt Way, Suite 107, Sunnyvale, CA 94086, (408) 245-2138.

Inquiry 606.

Ethernet for the Macintosh II

3Com Corporation and Apple Computer have jointly developed an Ethernet network interface for the Macintosh II. The adapter, which is being sold by Apple, is called EtherTalk.

Using EtherTalk, a Mac II can link directly to a 10-megabit-per-second Ethernet network such as 3Com's 3System. The board is designed to take advantage of the Mac II's NuBus architecture.

Price: $899.

Contact: Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.

Inquiry 607.

continued

THE WORLD'S SMARTEST ANSWERING MACHINE

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

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

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

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

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

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

OUTGOING MESSAGES
"This is Joel's computer calling. Just a reminder for Lynne and Bonnie — We have a budget review tomorrow morning at 8:00 o'clock. See you there."

Answering 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.

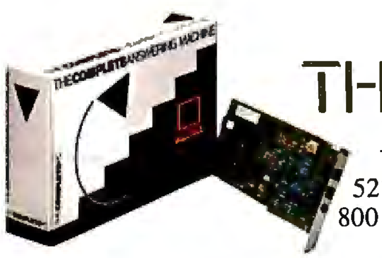
But give your friends and associates their own voice mailboxes. The ability to interrupt your greeting and start recording immediately. To deliver messages to each other as well as to you. The ability to transfer to other extensions. Even let them change their minds *and* their messages. Give them all 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.



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800 634-5558 • 408 434-0145 • FAX 408 434-1048

SOFTWARE • ROGRAMMING LANGUAGES AND AIDS

Blyth Announces Omnis Products

Express is a new applications-development front end for the Omnis 3 Plus relational database, which runs on the Macintosh. The utility will be an integral part of all Omnis 3 Plus packages and will enable Omnis 3 users to develop a working database in near-record time using Express alone, Blyth reports. The process involves defining only the database files and fields, after which Express automatically generates all screens, menus, and reports. If you're not satisfied with the designs created by Express, you can further customize the forms by using the usual Omnis 3 Plus commands.

Blyth also announced plans for a Windows-based superset of Omnis 3 for the IBM PC, which will give users simultaneous access to the Omnis database from IBM PCs and Macs.

Price: stand-alone version of Express, $99; Express bundled with Omnis 3, $575.

Contact: Blyth Software Inc., 2929 Campus Dr., Suite 425, San Mateo, CA 94403, (415) 571-0222.

Inquiry 608.

A Crib Sheet for Macintosh Programmers

The Programmer's On-Line Companion is a disk-based database reference to *Inside Macintosh,* volumes I through IV and the *Apple Numerics Manual.* The program controller resides in 5K bytes of RAM, and the references can be accessed from the editor screen. You can also add to or modify the system calls, system globals, and assembly equate definition in the volumes.

The Programmer's On-Line Companion runs on the 128K Mac, 512K Mac, and the Macintosh Plus.

Price: $34.95.

Contact: Addison-Wesley Publishing Co., Jacob Way, Reading, MA 01867, (617) 944-3700.

Inquiry 609.

Prolog for the 80286

VMV Prolog is the first Prolog that allows full use of the 16-megabyte address space of the 80286, according to Automata Design Associates. It runs with Xenix-286 or Microport's System V, or on AT&T's 6300 Plus with AT&T Unix System V.

A.D.A. reports that you can communicate with an unlimited number of concurrent processes by System V messages, and the language can serve as the record-locking manager for a Prolog database.

The company is planning an 80386 version, which will take advantage of the core 32-bit design of VMV Prolog.

Price: $400.

Contact: Automata Design Associates, 1570 Arran Way, Dresher, PA 19025, (215) 646-4894.

Inquiry 610.

Network Operating System for PS/2 Line

VINES/386 is a network operating system for 80386 systems, and, according to Banyan, it is compatible with the IBM PS/2 Models 80, 50, and 60. The program provides communication with asynchronous hosts via VT-100, VT-52, IBM3101, and TTY emulation. File transfer through the Kermit protocol is also available.

A VINES/386-based server connects to a LAN by installing a LAN interface board into an empty slot in the IBM PC.

Banyan Systems reports that shipments for the first version, which runs on the Compaq 386, will begin November 1, 1987.

Price: $3995.

Contact: Banyan Systems Inc., 115 Flanders Rd., Westboro, MA 01581, (617) 898-1000.

Inquiry 611.

SOFTWARE • BUSINESS AND OTHER

Crosstalk Mk.4

Crosstalk Mk.4, an enhancement of the Crosstalk communications program, features CASL (Crosstalk Application Script Language), which includes statements, operators, and functions that enable you to manipulate windows, data files, and numeric and alphanumeric data. Up to 15 communications sessions can take place simultaneously in windows or individually in full-screen format.

Mk.4 supports Crosstalk, Kermit, Xmodem, and Ymodem file-transfer protocols and emulates many terminals, according to Digital Communications Associates. The company also reports that the program supports all asynchronous, full-duplex modems.

The program runs on IBM PCs and compatibles with MS-DOS or PC-DOS 2.0 or higher and at least 256K bytes of RAM.

Price: $245.

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

Inquiry 612.

Accounting Module for VP-Planner

CPA+ is an integrated accounting module that includes checks, deposits, payables, sales/receivables, and payroll functions. Inventory and job-costing functions are in the works for future versions, according to FrontRunner Development, the company that designed the module in conjunction with Paperback Software.

The module does not have an audit trail capability, although the company reports that enhancements are in the works at this time. Written with VP-Planner macros, you do have the capability to customize the module by modifying certain routines.

VP-Planner runs on IBM PCs and compatibles with at least 256K bytes of RAM (or 320K when using multidimensional files), MS-DOS or PC-DOS 2.0 or higher, and a CGA, EGA, or Hercules Monochrome Graphics Adapter.

Price: $199.

Contact: Paperback Software, 2830 Ninth St., Berkeley, CA 94710, (415) 644-2116.

Inquiry 613.

ApTech Announces First Product

Called a Daily Business Tool, Abraxas is a window-based accounting and management program for small- and medium-size businesses. As you enter checks, deposits, sales, invoices, and time cards, Abraxas posts debits or credits in real time to all accounts, creating a complete audit trail. It balances your

continued

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Our Mouse and Publisher Software is the complete solution for people who want to produce great looking, attention getting documents without having to master a lot of complex commands and typographical jargon. It's easy to learn, fast to use, and it gets you the results you need right now.

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Select from over 61 fonts representing 14 typefaces, in sizes suitable for headlines, subheads and text. We provide optimal line spacing automatically. You adjust for special effects.

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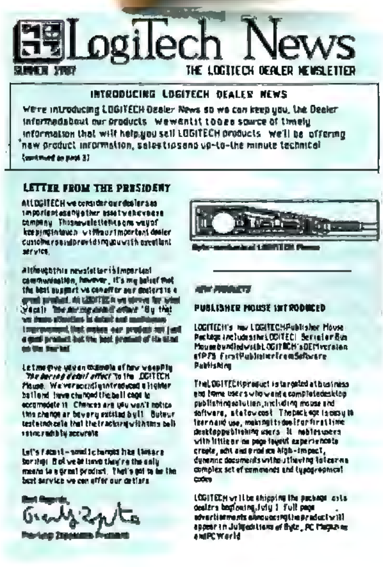

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Inquiry 146 for End-Users. Inquiry 147 for DEALERS ONLY.

SOFTWARE • BUSINESS AND OTHER

books and updates client and vendor lists. ApTech reports that it is impossible to duplicate transactions.

The program is written in Nantucket Clipper. It includes user-defined color capability and comes in single-user and multiuser versions. The single-user version is currently available and requires an IBM PC or compatible with at least 512K bytes of RAM and a hard disk drive. The multiuser version is scheduled for release in September.

Price: single-user version, $695.

Contact: ApTech Inc., P.O. Box 2366, Binghamton, NY 13902, (800) 443-3732.

Inquiry 614.

QuikSave's warning screen alerts you when a backup is necessary.

QuikSave Forces You to Back Up Your Hard Disk

QuikSave is a backup program that you store on your hard disk. You can assign up to nine backup schedules, and during power-up the program calculates the number of days since each backup. When it's time for a backup, the program flashes a warning screen. Then it asks if you want a backup, which it will perform automatically, or you can tell it to wait until the next day. If you have a clock, it will automatically remind you; otherwise, it will wait for you to enter the date. QuikSave also lets you see when the last backup occurred for each person with a backup schedule.

Micro Interfaces reports that the program performs a disk check, making sure that your disk is error-free before backing up data.

On IBM PC XTs, it can back up 10 megabytes of data in less than 8 minutes, and it can back up the same amount in 4 minutes on IBM PC ATs and compatibles. It corrects up to 3200 errors per floppy disk and is capable of backing up 360K-byte, 720K-byte, and 1.2-megabyte floppy disk drives. You can store 400K bytes on 360K-byte floppies and 1.5 megabytes of information on 1.2-megabyte floppies.

The program runs on IBM PCs, XTs, ATs, and compatibles with MS-DOS or PC-DOS 2.0 or higher and at least 360K bytes of RAM.

Price: $99.

Contact: Micro Interfaces Corp., 16359 Northwest 57th Ave., Miami, FL 33014, (800) 637-7226.

Inquiry 615.

Keep Track of 177 Countries on a PC

PC-Globe gives you access to 177 countries on world and continent maps, and with overlays you can show major cities, population densities, and elevations.

Using the database, you can display information on demographics, health statistics, political parties, economic trends, and balance of trade statistics. Other data includes climate, currencies, time zones, and tourist attractions. In another table, you can see countries ranked in terms of population, area, economic growth, and commodity production.

The program comes on six 5¼- or 3½-inch floppy disks, and it is copy-protected. You can copy PC-Globe to a hard disk up to four times.

The program runs on IBM PCs, XTs, ATs, and compatibles with two floppy disk drives or one floppy and one hard disk drive. At least 256K bytes of RAM is required along with MS-DOS 2.0 or higher and a Color Graphics Adapter.

Price: $59.95.

Contact: Comwell Systems Inc., 21630 North 19th Ave., Suite B-4, Phoenix, AZ 85027, (602) 869-0412.

Inquiry 616.

Project Tracker

InstaPlan offers you seven views for developing a plan interactively and turning it into a presentation. Using outline-based activity scheduling, you lay out your projects from the top down in a natural list-making format. Outlines can have up to 11 levels, and they are automatically indented. Each level summarizes schedules, human resources, and cost, and you can create a rough plan and see schedules and budgets. As the project develops, you don't have to undo the details you've already entered. You can output the information in tabular, Gantt, and presentation form.

You can assign work to groups of people or individuals, and the spreadsheet has columns you can use for people or budgets and rows for activities. After you assign the work, the program automatically summarizes what it will cost and how many people it will take. If any individual becomes overworked with one assignment, you can let InstaPlan redivide the work, and the program makes the necessary changes to budget and worker-hour totals. On a 640K-byte IBM PC or compatible, you can have over 600 activities.

The tracker module features a reference plan system that allows for detailed variance analysis from individual work assignments to the total project: tracking schedule, human resources, budget, and cash-flow control. The tracker module is an option, and it adds three additional variance views.

A calendar is provided with the program, which you can set up with holidays and vacations for InstaPlan to take into account when assigning work.

The program has desktop-presentation facilities that create overhead slides, proposals, and handouts on the IBM Proprinter or graphics printer, Epsons and compatibles, and the Hewlett-Packard LaserJet Plus.

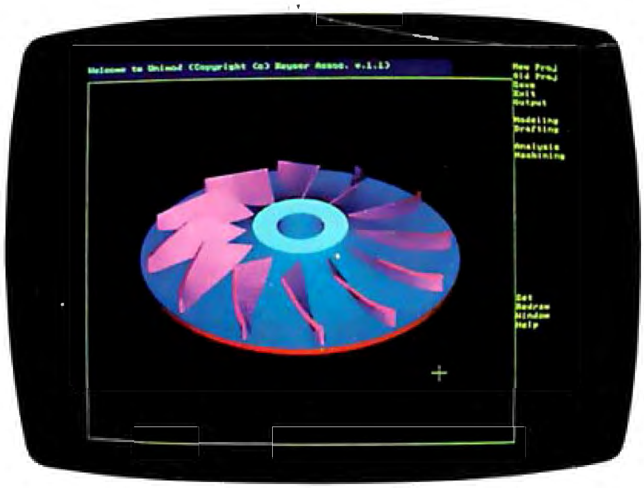
InstaPlan runs on IBM PCs and compatibles with at least 640K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher.

Price: $99; tracker option, $50.

Contact: InstaPlan Corp., 655 Redwood Hwy., Suite 311, Mill Valley, CA 94941, (415) 389-1414.

Inquiry 617.

SOFTWARE • SCIENTIFIC AND ENGINEERING



A three-dimensional machine tool modeled by Unimod.

Numerical Control Modeling on the IBM PC

Unimod is a three-dimensional solid-modeling program that generates numerical control instructions for machine tools. The program runs on an IBM PC, XT, AT, or compatible with a 10-megabyte hard disk drive, 640K bytes of RAM, a math coprocessor, and an EGA or CGA.

The Unimod solid modeler is integrated with Encode's Encodraft mechanical drafting system, which is an add-on program for use with AutoCAD. After designing the model on the IBM PC with Encode's Encodraft program, Unimod generates the machine cutting instructions. A library of 3500 machine-specific postprocessing routines are included that you can use to send instructions to specific types of machine tools, such as lathes or milling machines. Encode also uses a machine-instruction programming language, called Genesis, which you can modify for special applications. You can also interface the system to a variety of finite-element programs such as NASTRAN, Patran, and ANSYS.

Price: between $5000 and $8000.
Contact: Encode Inc., 12 Cotton Rd., Nashua, NH 03063, (603) 882-4666.
Inquiry 618.

Unit Conversion

QuikInfo is a memory-resident program that lets you convert horsepower to kilowatts or gallons to cubic feet, or any number into its equivalent unit in another measurement system. Hundreds of conversions are possible, and the equivalencies are grouped by category. You can also export and import to and from other application programs. Other information is available in the program, such as common engineering and scientific physical constants. And you can add or delete conversion units or tables and position windows, screen colors, and other appearance items as well.

To run QuikInfo, you need an IBM PC or compatible with at least 80K bytes of RAM.
Price: $49.
Contact: Plies Development Corp., 2110 Crystal Hills, Houston, TX 77077, (713) 493-3679.
Inquiry 619.

Two-Dimenional CAD Program Cut to $99

MSA Group has cut the price on TurboCAD from $395 to $99. The program features automatic dimensioning, drafting capabilities, and dot-matrix printing. You also have the choice of operating in menu-driven or command-driven mode.

Drawing tools include up to 256 line thicknesses, 100 line and arrow types, user-definable hatching patterns and grid, zoom, and three cursor types. You can define circles seven ways, and the program provides 128 layers. Other features include windowing facilities, a scientific calculator, print spooling, the ability to configure the program for up to 10 output devices at a time, and DXF, HPGL, and ASCII file formats.

MSA also announced version 2.0 of TurboCAD, which will feature multiple views, three dimensions, speed enhancements, extended file exchangeability, a macro language, and improved zoom and pan capabilities.

TurboCAD runs on the IBM PC, XT, AT, and compatibles and supports most digitizers, plotters, printers, and mice, according to MSA.
Price: $99.
Contact: MSA Group Inc., 12021 Wilshire Blvd., Suite 370, West Los Angeles, CA 90025, (213) 473-8711.
Inquiry 620.

New Titles in Chemistry Series

COMPress added three new programs to the Concepts in General Chemistry series. They emphasize drill and practice for introductory chemistry students. Diagnostic error evaluation lets the student know what terms are incorrect or if the error is in the formula or coefficient.

Chemical Reactions provides practice in writing and balancing equations for combination, decomposition, replacement, and ionic reactions. The next program, Oxidation-Reduction Reactions, focuses on balancing oxidation-reduction equations and offers 70 problems that cover both acidic and basic media. The last program, Reaction in Aqueous Solution, contains 239 problems covering precipitation reactions, weak electrolyte formation, and formation of partially soluble gases. Other titles in the series include Chemical Stoichiometry and The Mole Concept.

The series runs on an IBM PC with at least 256K bytes of RAM, a CGA, and a graphics monitor.
Price: $50 per title.
Contact: COMPress, P.O. Box 102, Wentworth, NH 03282, (603) 764-5225.
Inquiry 621.

Drawing Chemical Structures on the Mac

ChemIntosh DA from SoftShell is a desk accessory that enables you to draw a chemical structure and transfer it to your word-processing document, without leaving the word processor.

The program has tools for placing symbol strings, drawing nine bond types, and four straight arrows, which include reaction, equilibrium, resonance, and dashed. It has an undo facility, on-line help, and other features that let you print, resize objects and text, and save and open documents. You can draw solid or dashed circles, ovals, and arcs by dragging the mouse outside the circle or oval to specify the desired arc.

The program runs on the Macintosh and requires a minimum of 512K bytes of RAM and two floppy disk drives or a hard disk drive.
Price: $295.
Contact: SoftShell Co., P.O. Box 632, Henrietta, NY 14467, (716) 334-7150.
Inquiry 622.

WHAT MAKES THE ALPS SO SPECIAL, ANYWAY?

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There's something for everyone in the ALPS.

Because the ALPS family of Dot Matrix Printers has everything it takes to handle any business need.

Need a printer that can take on a department full of PCs?

Then look at our P2000 Series.

There's our top-of-the-line P2400C,™ which zips along at 360 cps, prints 7 colors and is jam packed with smart features. Our amazingly fast black-and-white P2100,™ with a cruising speed of 400 cps. And our P2000,™ voted one of

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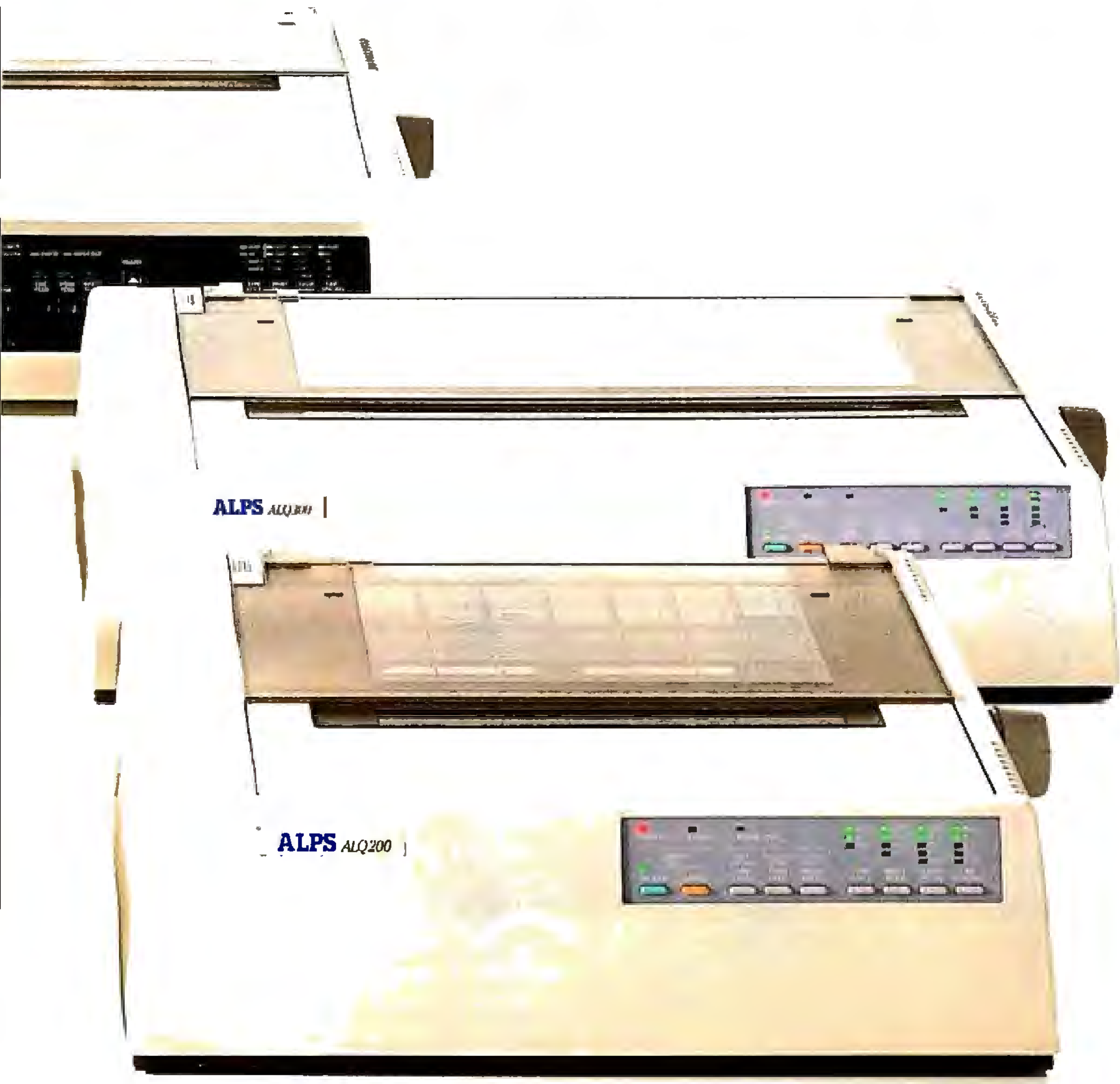


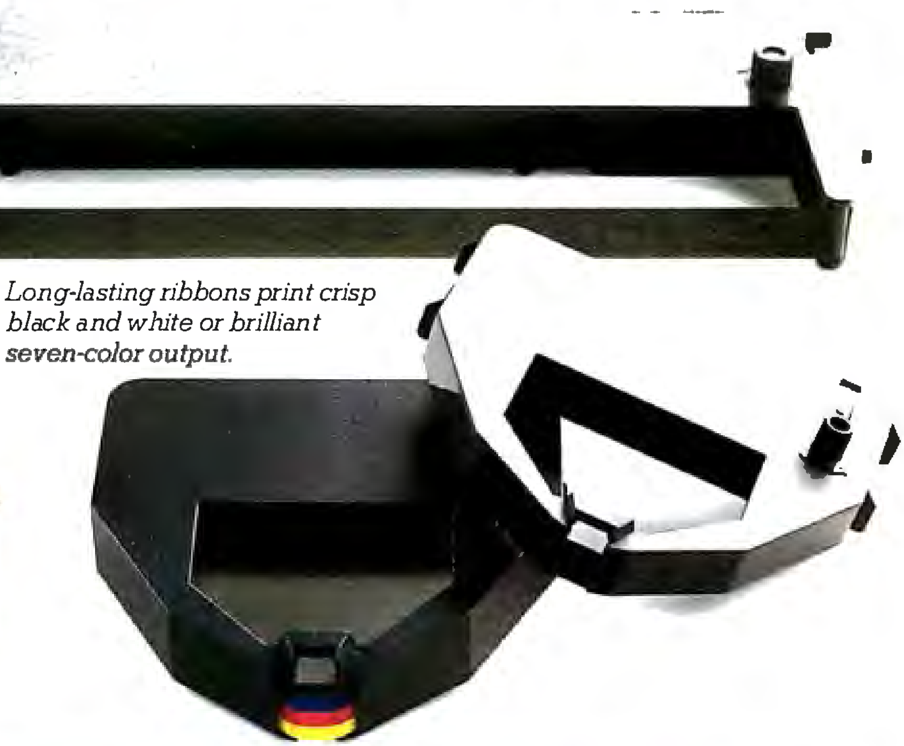
PC Magazine's "Best of 1986."

If you need something more personal, try our ALQ Series. Both the ALQ300™ and ALQ200™ print superb letter quality text and high resolution color graphics. And they do it quickly, easily and economically.

But whichever ALPS you choose, you'll find they all have something in common. Each is an exceptionally well thought out machine.

To see how, our tour continues on the next page.

RE MANY INTEREST.



Long-lasting ribbons print crisp black and white or brilliant seven-color output.

the job may be, our control panel makes it simple. You just push a button to change type styles, feed paper, reprint data, or do most anything else.

As for compatibility, ALPS printers run with most all the leading PCs and software.

Best of all, they're especially compatible with the way you run your business.

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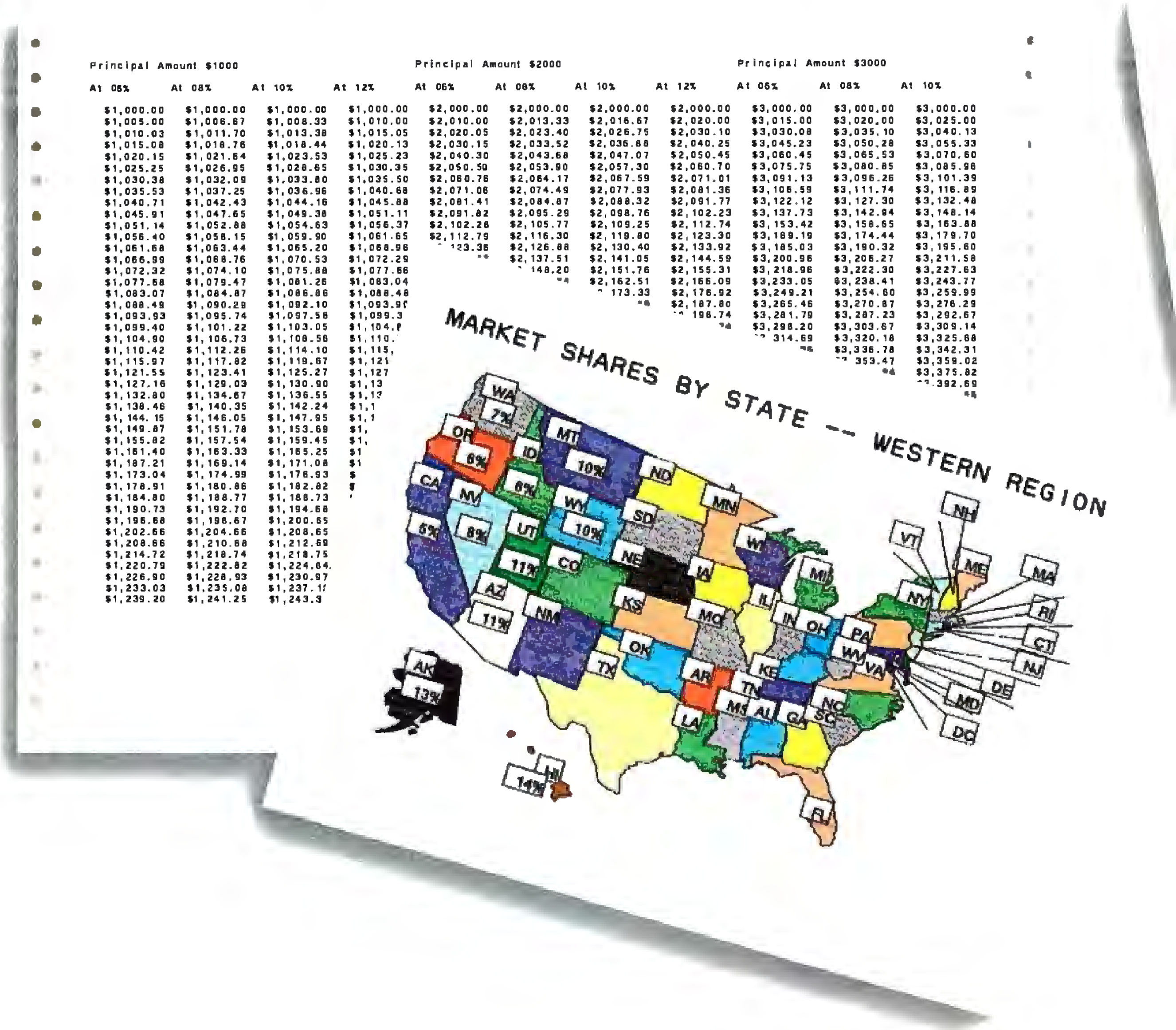
ARE SPEC



Here's something you probably won't see in any other printer ad.

Namely, everything from letter quality text and high resolution color graphics to transparencies, 16-inch-wide spreadsheets and six-part forms.

Fact is, most printers can't handle such a wide range of work. Then again, most aren't built like the ALPS.

Our printheads are precisely engineered to produce exquisite letter quality text. Yet they're rugged enough to churn out over 200 million characters. No matter how hard you work them.

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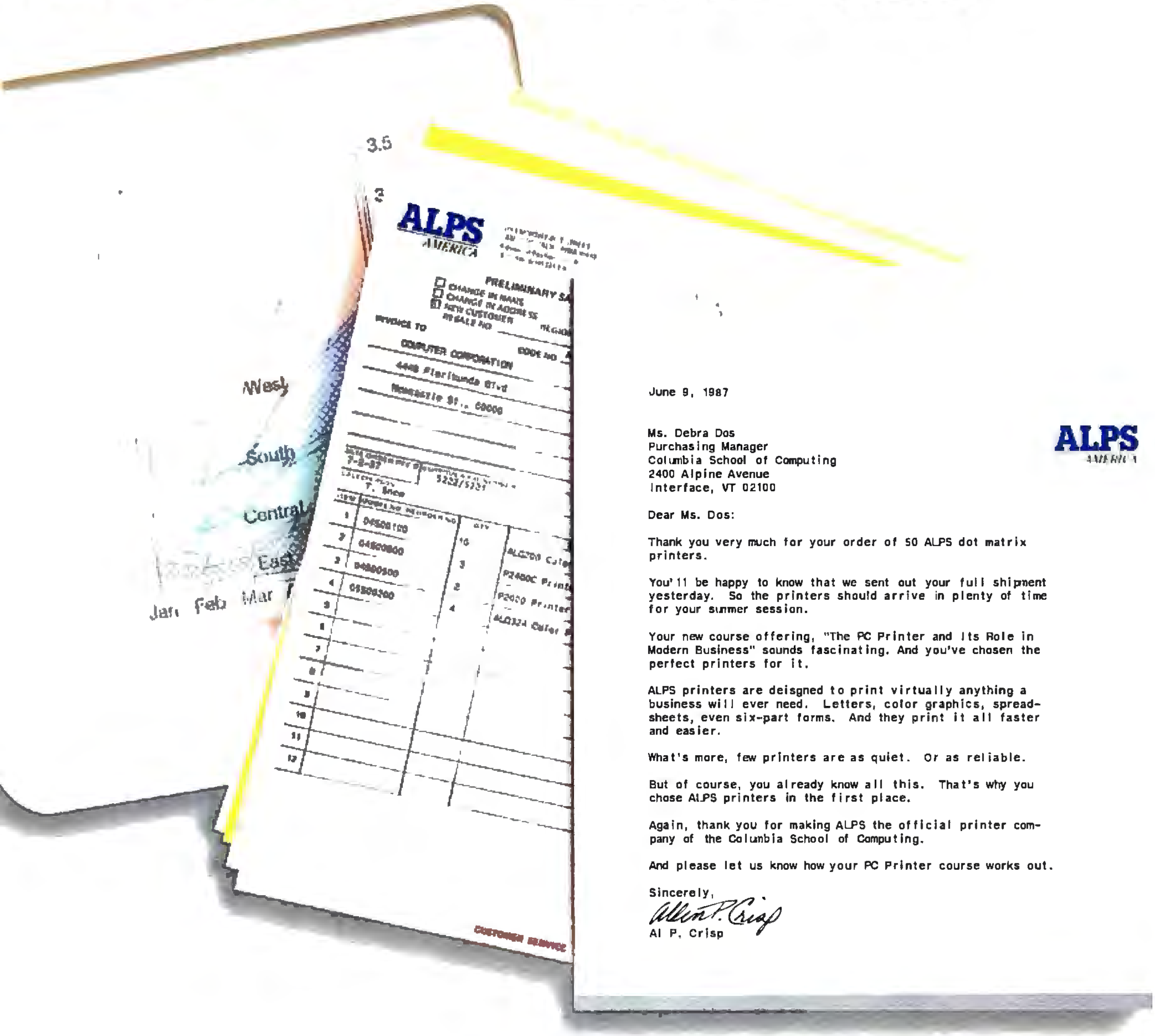


And because the ALPS are compatible with all kinds of software, they can produce all kinds of images. Plus, if you haven't heard, they run at exceptionally quiet noise levels of under 55 dBA.

What's more, they'll run for what seems to be forever. They come with a full one-year limited warranty. And with normal care, they'll give you over five years of spectacular work. Without a speck of trouble.

Can any other printer make you look this good?

AND THE CR

"...the speed, print quality, and other thoughtful features of the ALPS P2000...make this wide-carriage 9-pin matrix printer my favorite new printer of the year."

–PC Magazine

"The ALPS ALQ300 and P2400C are both rugged wide-carriage dot matrix printers with excellent letter quality type..."

–PC Magazine

"ALPS America keeps on coming back with more attention-getting dot matrix printers."

–PC Magazine

"To distinguish letter-quality from daisywheel output requires a magnifying glass."

–PC Week

As you can see, our printers even have the best ink.

But if you're the type who's not easily swayed by popular opinion, consider this:

Since our first printers were introduced in the U.S. in late 1985, ALPS America has become one of the fastest growing printer companies in the country.

Which should come as no surprise.

After all, ALPS printers are built

ITICS AGREE.

"...so quiet that we doubt even a library would need the 'quiet' mode."

—*InfoWorld*

"...its controls are the most accessible of any printer we have used..."

—*InfoWorld*

"In almost every phase of construction, ALPS seems to have relied on sturdier materials than it might have had to—something which is a definite advantage for the user."

—*PC Products*

"...a real workhorse printer that prints faster than others in its price range and is loaded with features..."

—*PC Products*

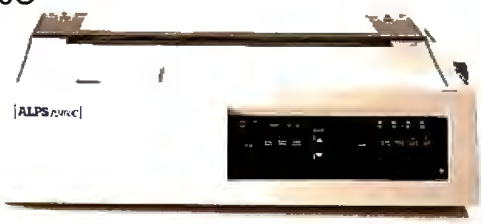
by ALPS Electric, a $2.0 billion, International Fortune 500 company that's been successfully manufacturing and marketing computer printers worldwide for over a decade.

And doing so by following a very simple idea.

To bring you the most intelligent, versatile and reliable business printers on the market.

At prices you can't help but agree with.

SO HERE'S Y
TO TH

MACHINE	PRINT METHOD	PRINT MODE/SPEED		
P2000 	9-pin serial dot matrix. Black and white.	Draft 250cps Correspondence 125cps Letter quality 50cps		
P2100 	18-pin serial dot matrix. Black and white.	Draft 400cps Correspondence 200cps Letter quality 80cps		
P2400C 	18- or 24-pin serial dot matrix. Color and black and white.	 Draft Correspondence Letter quality	24-pin 360cps 180cps 120cps	18-pin 250cp 125cp
ALQ200 	18- or 24-pin serial dot matrix. Color and black and white.	 Draft Correspondence Letter quality	24-pin 240cps 120cps 80cps	18-pin 200cp 100cp
ALQ300 	18- or 24-pin serial dot matrix. Color and black and white.	 Draft Correspondence Letter quality	24-pin 240cps 120cps 80cps	18-pin 200cp 100cp

OUR GUIDE
E ALPS.

INTERFACE	PAPER FEED	BUFFER	EMULATIONS	SIZE	SPECIAL FEATURES
Centronics parallel and RS-232C serial ports standard.	Push/pull tractor, bottom and rear feed, automatic single sheet loading standard. Single bin sheet feeder optional.	4KB standard, expandable to 260KB.	Epson FX and MX Series	Width: 24.4″ Depth: 16.5″ Height: 5.5″ Weight: 33 lbs. Carriage width: 16.5″ 136 columns at 10 pitch. 272 columns at 20 pitch.	Two font cartridge slots. Automatic copy feature. Quiet, below 55dBA operation. Excellent multi-part forms capability. 1-year warranty.
Centronics parallel and RS-232C serial ports standard.	Push/pull tractor, bottom and rear feed, automatic single sheet loading standard. Single bin sheet feeder optional.	4KB standard, expandable to 260KB.	Epson FX and MX Series, DEC.	Width: 24.4″ Depth: 16.5″ Height: 5.5″ Weight: 37.9 lbs. Carriage width: 16.5″ 136 columns at 10 pitch. 272 columns at 20 pitch.	Two font cartridge slots. Automatic copy feature. Quiet, below 55dBA operation. Excellent multi-part forms capability. 1-year warranty.
Centronics parallel and RS-232C serial ports standard.	Push/pull tractor, bottom and rear feed, single sheet automatic paper loading standard. Single and dual bin sheet feeder optional.	4KB standard, socketed for easy expansion to 260KB.	Epson LQ, FX, JX, EX and MX Series.	Width: 25.4″ Depth: 17.7″ Height: 7.09″ Weight: 43.7 lbs. Carriage width: 16.5″ 136 columns at 10 pitch. 272 columns at 20 pitch.	Two font cartridge slots. Snap in/out print head. Special printing features selected via menu, control panel or software. Quiet, below 55dBA operation. 1-year warranty.
Centronics parallel port standard, RS-232C serial port optional.	Fan-fold bottom and rear feed, single sheet automatic paper loading standard. Bi-directional tractor, single and dual bin feeder optional.	7KB standard, expandable via plug-in buffer cartridge to 71KB.	Epson LQ, FX, JX, EX and MX Series.	Width: 18.5″ Depth: 15.8″ Height: 5.6″ Weight: 30.9 lbs. Carriage width: 11.5″ 80 columns at 10 pitch. 160 columns at 20 pitch.	One font cartridge slot. Snap in/out print head. Special printing features selected via menu, control panel or software. Quiet, below 55dBA operation. 1-year warranty.
Centronics parallel port standard, RS-232C serial port optional.	Fan-fold bottom and rear feed, single sheet automatic paper loading standard. Bi-directional tractor, single and dual bin feeder optional.	7KB standard, expandable via plug-in buffer cartridge to 71KB.	Epson LQ, FX, JX, EX and MX Series.	Width: 24.1″ Depth: 15.8″ Height: 5.6″ Weight: 37.5 lbs. Carriage width: 16.5″ 136 columns at 10 pitch. 272 columns at 20 pitch.	One font cartridge slot. Snap in/out print head. Special printing features selected via menu, control panel or software. Quiet, below 55dBA operation. 1-year warranty.

EVENTS

August 1987

IEEE/ACM Symposium on the Simulation of Computer Networks, Colorado Springs, CO. Mitchell Spiegel, GTE Systems, 1700 Research Blvd., Rockville, MD 20850, (301) 294-8400. *August 5–7.*

International Computers in Engineering Conference and Exhibition, New York, NY. American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017, (212) 705-7795. *August 9–13.*

Financial and Accounting Decision Making Using Lotus 1-2-3 Release 2.0, Dallas, TX; Atlanta, GA; Orlando, FL; Arlington, VA. Data-Tech Institute, Lakeview Plaza, P.O. Box 2429, Clifton, NJ 07015, (201) 478-5400. *August 10–11; August 12–13; August 20–21; August 27–28; respectively.*

Modern Techniques in Digital Signal Processing and Analysis, Santa Cruz, CA. Institute in Computer Science, University of California Extension, Santa Cruz, CA 95064, (408) 429-4535. *August 10–12.*

How to Install a Statistical Quality Control System, Albany, NY; Buffalo, NY; St. Louis, MO. LaVerne Johnson, Qualityalert Institute, 420 Lexington Ave., Suite 2846, New York, NY 10017, (212) 878-9600 or (800) 221-2114. *August 10–13; August 24–27; August 25–28; respectively.*

Computer Graphics, Sunnyvale, CA. Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151. *August 10–14.*

Systems Analysis and Design Workshop, Hartford, CT. Don Florek, Graduate Center, 275 Windsor St., Hartford, CT 06120, (203) 548-2470. *August 10–14.*

Introduction to Telecommunications, Cambridge, MA. Lesley College Graduate School, 29 Everett St., Cambridge, MA 02238, (617) 868-9600, extension 362. *August 11, 13, and 17–21.*

Relational Database Systems, San Francisco, CA. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *August 11–14.*

Art-X'87 Seminar and Showcase for Electronic Art, Design and Graphics, Washington, DC. Carl Littauer, 808 Loretta Dr., River Vale, NJ 07675, (201) 391-7532. *August 12–14.*

Networking the IBM PC, XT, AT and Compatibles, Seattle, WA; Washington, DC; Chicago, IL. Ann Molinari, Data-Tech Institute, P.O. Box 2429, Lakeview Plaza, Clifton, NJ 07015, (201) 478-5400. *August 13–14; August 17–18; August 20–21; respectively.*

Fourth Conference on Writing for the Computer Industry, Cambridge, MA. Dr. Edward Barrett, Director, Room 14E-310B, MIT, Cambridge, MA 02139, (617) 253-7894. *August 15.*

Ninth International Conference on Production Research, Cincinnati, OH. Dr. Ernest L. Hall, University of Cincinnati, ML 72, Cincinnati, OH 45221. *August 17–20.*

Professional Courses from The Omnicom Institute, Boston, MA. Omnicom Inc., 115 Park St. SE, Vienna, VA 22180, (703) 281-1135. *August 17–21.*

TEX Users Group's Annual Conference and Regional Courses, Seattle, WA. Raymond E. Goucher, P.O. Box 9506, Providence, RI 02940, (401) 272-9500, extension 232. *August 17–28.*

Inexpensive Alternatives in Powerful Spreadsheets, Atlanta, GA. Deidre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *August 18.*

How to Manage Software Projects, Washington, DC. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *August 18–21.*

Designing Industrial Systems for EMC, Milwaukee, WI. Peter Tocups, University of Wisconsin-Milwaukee, Center for Continuing Engineering Education, 929 North Sixth St., Milwaukee, WI 53203, (414) 227-3125. *August 19–21.*

Second Annual COMDEX/Australia, Sydney, Australia. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. *August 19–21.*

Colorimetry: An Intensive Short Course for Scientists and Engineers, Rochester, NY. Christine Kester, Munsell Color Science Laboratory, Rochester Institute of Technology, One Lomb Memorial Dr., P.O. Box 9887, Rochester, NY 14623-0887, (716) 475-5842. *August 24–27.*

C Programming Workshop, Pleasantville, NJ. Plum Hall, 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770. *August 24–28.*

High-Performance Computer Architectures, Palo Alto, CA. Tom Watson, Integrated Computer Systems, 5800 Hannum Ave., P.O. Box 3614, Culver City, CA 90231-3614, (213) 417-8888; (800) 421-8166. *August 25–28.*

1987 Annual International Test Conference, Washington, DC. Doris Thomas, ITC, P.O. Box 264, Mt. Freedom, NJ 07970, (201) 895-5260. *August 30–September 4.*

Artificial Intelligence—and Other Innovative Computer Applications in the Nuclear Industry, Snowbird, UT. Idaho Section, American Nuclear Society, P.O. Box 2196, Idaho Falls, ID 83403-2196, (208) 526-7214. *August 31–September 2.*

European Conference on Artificial Intelligence in Medicine, Marseilles, France. Institut International de Robotique et d'Intelligence Artificielle de Marseilles, 2, rue Henri-Barbusse, CMCI, 13241 Marseilles, France, 91-91-36-72. *August 31–September 3.*

Symposium on Logic Programming, San Francisco, CA. David S. Warren, 1310 Villa St., Mountain View, CA 94041, (415) 965-7700. *August 31–September 4.* ■

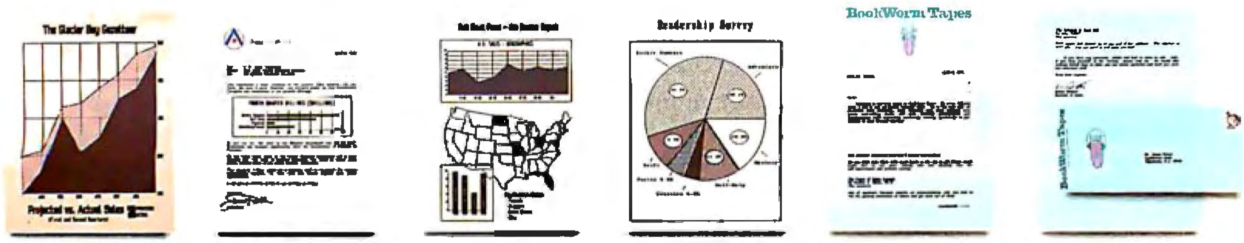
Send notice of your organization's public activities at least four months in advance; we will publish them as space permits. Please send them to BYTE (Events), One Phoenix Mill Lane, Peterborough, NH 03458.

New power to the printed page.

The new IBM printers.

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

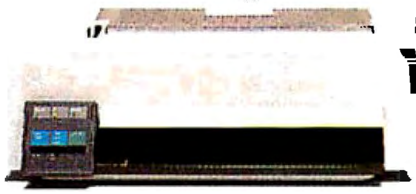
But what comes out of your printer goes out to the world.



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.

The IBM Proprinter II.

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

So what do you get more of in the Proprinter II?

Speed, versatility and convenience. There's now Fastfont,™ an extra-fast draft mode. Switching to "near 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 both text and graphics, with a printer that's fast and economical.

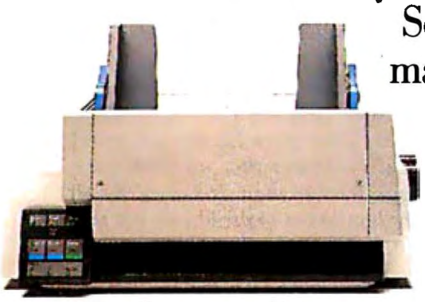
The IBM Proprinter X24 and Proprinter XL24.

The IBM Proprinter X24 and Proprinter XL24 are new. The "24" stands for 24-wire technology. What *that* stands for is new levels of Proprinter quality for everything you put on paper.

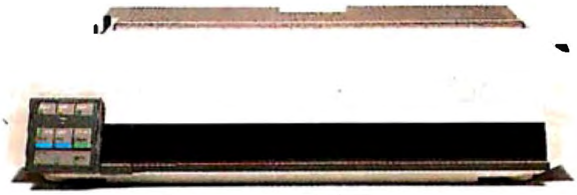
Both models print letter quality text with greater detail and graphics with better density and definition.

The improvement is easy to see.

So is the performance. When



The IBM Proprinter X24 with optional sheet feed.



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

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

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

The IBM Quietwriter III Printer.

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

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

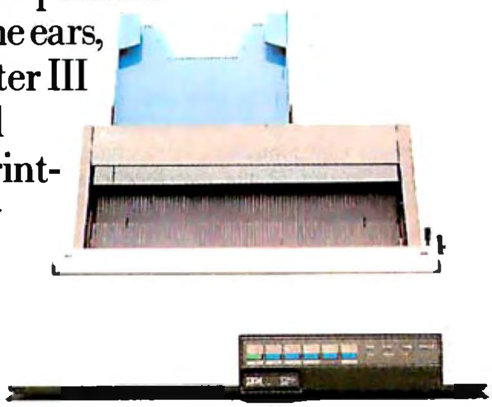
If that's not enough, there are optional font cartridges that give you the freedom to use up to eight typestyles on one page.

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

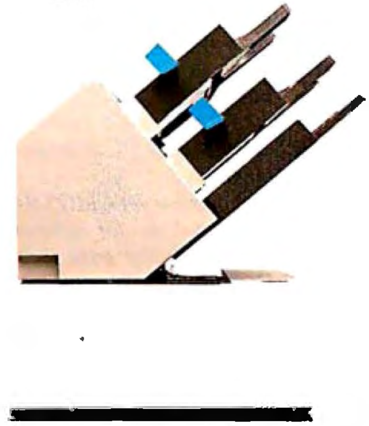
No matter what level of price or performance you need, there's an IBM personal printer to fit the bill. And they fit very nicely with the IBM Personal System/2.™

So call your IBM Marketing Representative, or visit an IBM authorized dealer.

For the dealer nearest you, call 1-800-447-4700, ext. 9. (In Alaska call 1-800-447-0890, in Canada 1-800-465-6600.) IBM®



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



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

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

ASK BYTE

Conducted by Steve Ciarcia

Boot-Up Blues

Dear Steve:

I have a problem that many may share and that you may be able to solve. I have a PC clone with two floppy disk drives. When I turn it on, my AUTOEXEC.BAT file manipulates 300K bytes worth of utilities that include initializing a RAM disk, installing a keyboard accelerator and a screen saver, and copying WordStar and SDIR to the RAM disk. It takes about a minute, and the wait is annoying.

I want to speed up this process, and I also would like to add more startup programs. The obvious solution is a hard disk, but I don't like that idea. It is bound to become the least reliable part of my system, and hard disks are noisy. I already have to live with a muffin fan for the power supply. (What happened to the piezoelectric butterfly fans that were going to replace muffin fans?)

My ideal solution would be a virtual disk made from a 1- or 2-megabyte EEPROM card that I could write to (albeit slowly, I realize). This would let me load my favorite programs once and for all and have them ready as soon as I flip the switch. And I would still be able to revise the EEPROM disk as needed.

It would be wonderful if the hardware for this product came from your Circuit Cellar. Software should be easy, very close to a regular VDISK.

Maurice Gueron
Paris, France

The only problem with a 1- or 2-megabyte EEPROM is the rather staggering cost. An 8K-byte EEPROM costs about $10 in moderate volumes, so a megabyte will set you back about $1250, without the card or other components. Fitting the requisite 128 devices on a PC card would also be a problem.

Actually, you can now get CMOS RAM cards with a few megabytes for somewhat less money (although the cost is still pretty stiff). They use little enough power that you can back them up by an external battery while the PC is turned off.

The software to drive the card would be like the standard VDISK code, except it must first check the RAM to see if anything is stored there (perhaps by using a checksum). You'd also need a way to keep the PC from running its diagnostic checks on the RAM during power-up.

The most cost-effective way to do what you want is to add the dreaded hard disk. I agree that hard disks are noisy, but you'd be surprised at how reliable they are if you don't mistreat them (by moving them when they're on or dropping them when they're off). At about $500 for 20 megabytes, it's certainly a better deal than the EEPROM, and you can junk that pile of floppies in your desk drawer.

A solution to the noise problem is to get an external hard disk and put it in a soundproof enclosure. You'll need to figure out a way to move the heat out, but a baffle duct and a quiet fan will do the trick. I've seen it done and it works quite well.—Steve

Give Me More Power

Dear Steve:

I have two Franklin ACE 1000s. I like them, but I wish they were a bit more powerful.

In the January issue of BYTE (page 68), Jesse D. Sheinwald reviewed two books on 65816/65802 assembly language. He implied—or perhaps it is my wishful thinking—that you can replace a trusty old 6502 (or 65C02) with a 65802 simply by switching processors.

Is this correct? Can I just unplug my 65C02s and snap in 65802s to have what amounts to new 16-bit machines?

If this is the case, what—besides having to learn new assembly language—are the disadvantages? If the disadvantages are not substantial, what precisely would be the advantages? Also, where can I get a 65802?

Bernard Paul Sypniewski
Woodbine, NJ

You are not alone in your desire to replace the now-ancient 8-bit 6502-series processors with something more contemporary. Several of the interface cards available for Apples provide for 16-bit upgrades because of the widespread interest.

Although it was an exceptional microprocessor when it was first introduced in 1976, the 6502 is showing its age. It may be possible to simply replace your 65C02s with the newer 65802s, which are fully pin-compatible.

Unplugging the old and plugging in the new is the easy part. The catch is that the swap may not work.

Whether or not the switch works varies somewhat because of timing considerations. Problems seem to be most common with the older Apple II-series machines because of inadequate RAM data setup times. The Apple IIe and IIc computers and Franklins that use 64K-byte RAM chips (rather than 16K-byte RAM chips) are less prone to problems, but the success rate is still under 100%. However, Applied Engineering (P.O. Box 798, Carrollton, TX 75006) makes a RAM expansion card and companion 65816 card that eliminate interchange problems.

Disadvantages in making the switch are few: You might not be able to run software that uses invalid or unimplemented machine instructions (a once-popular method of "protecting" Apple software); and the current price of the 65802, from the only readily accessible source I know of (see below), is a steep $29.95.

In addition, you are unlikely to notice any difference at all unless you write your own code in assembly language with an assembler that implements the new instructions and 16-bit architecture. One such assembler is ORCA/M, available from:

BYTE WORKS
4700 Irving Blvd. NW
Albuquerque, NM 87114
(505) 898-8183

continued

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

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

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

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

News about the Microsoft Language Family

Writing Faster Progra s with Microsoft® C

Programmers switch to the large model because they've run out of room in the smaller models. Unfortunately, this can slow your program down by 20 to 30 percent. How can you write large model programs that run as fast as small model programs? Microsoft C can help you do this.

Segment Allocation Control

The Microsoft C Compiler Version 4.0 stores all initialized static data in a default data segment called DGROUP. Microsoft C keeps the address of the DGROUP segment in the DS register. This makes all references to initialized static data a faster NEAR reference even in large model. So the first trick is to make sure all of the data you use frequently is initialized and put into DGROUP. What do you do when you run out of DGROUP space? First, declare the initialized static data that you use less frequently as FAR. Declaring initialized static data FAR takes it out of DGROUP and puts it into a new data segment.

For example:

```
int count=0;          becomes    far int count=0;

main (argc, argv)                main (argc, argv)
int argc;                        int argc;
   .                                .
   .                                .
   .                                .
```

If you still run out of room in DGROUP, the new Microsoft C Optimizing Compiler Version 5.0 has another feature to keep your data access fast. The first step is to divide your external data into two files, data1.c and data2.c. The first file, data1.c, contains all of your DGROUP data such as initialized static data and variables you explicitly declare NEAR. The second file, data2.c, contains all of the data you declare FAR.

Microsoft C 5.0 puts all of the data declarations in the second file into a single new segment. Now create an include file using the #pragma same_seg to tell the compiler that all of the variables in the data2.c are in the same segment. Including this file in each module tells the compiler to load the new segment in the ES register and use the ES register when referring to variables in data2.c. Now references to data in both data1.c and data2.c will be faster NEAR references.

These are the kinds of features coming in the Microsoft C Optimizing Compiler Version 5.0 that will make your code faster than ever before.

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, cal (206) 882-8088. In Canada, call (416) 673-7638.

Latest DOS Versions:

Microsoft C Compiler	4.00
Microsoft COBOL	2.20
icrosoft FORTRAN	4.00
Microsoft Macro Assembler	4.00
Microsoft Pascal	3.32
icrosoft QuickBASIC	3.00

When writing your own code, many of the 6502's more frustrating limitations disappear: For instance, those 16-bit registers make a big difference when doing floating-point arithmetic.

The 65802 is not an easy bird to find, but it is currently being advertised for $29.95 by:

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002

—Steve

Optical Readers

Dear Steve:

I own an Atari 520ST with a memory upgrade and I program in assembly language. For my next project I want to make a page-reader to input printed material from books and magazines, into memory as ASCII codes. However, I can't find any information on the subject; I can't even find a commercial page-reader.

The only publication I have found that mentions any components is *Computer Shopper*, where I found an advertisement for a linear image sensor made by Fairchild. Are devices like this being suppressed by the publishers, or are they just too complicated to manufacture? There seems to be a need and a market in this country for such products.

Any help you can give me would be appreciated.

Lewis B. Pelow
St. Johnsbury, VT

There are several optical character readers available for use with personal computers. One of the earliest was originally marketed as the Oberon Omni-Reader, but the original maker is no longer in business. It can currently be purchased from California Digital and Jade Computer Products for $180 to $200 (these companies regularly advertise in BYTE). In addition, the current owner of marketing rights for the device is G.A.S. International (P.O. Box 1282, Euless, TX 76040), and that company is advertising it in Computer Shopper *magazine for $200. This is a price individuals can readily afford.*

More expensive devices are available from a variety of sources, with prices ranging from just over $1000 to well over $5000.

A review of five of these models for use with the IBM PC can be found in the April issue of BYTE ("Text Scanners for the IBM PC" by John McCormick, page 233).

I don't think there is a conspiracy to suppress character readers. The technology is still in its infancy and has been quite limited until recently. Test reports on the Oberon unit complained that very few type fonts are readable at all, and the error rate is high in any case. These problems could be solved with better software and more advanced image sensors, such as the CCD (charge-coupled device) units now becoming available, along with improved microprocessors such as the Motorola 68020 and Intel's 80386.

While character recognition seems quite easy for most people, programming a computer to recognize characters of varying sizes and in a variety of typefaces can be quite difficult. In the April BYTE review, by far the best performance was given by a unit with its own dedicated Motorola 68000 processor. The review plainly shows that performance is expensive: The highest-performing device costs over $5000, although prices should decline significantly as more products come on the market.

In addition, the legal problems created by widespread character-recognition technology must be addressed before that technology can flourish. Current copyright laws do not provide for translation of text into machine-readable form as a general practice, and many publications explicitly prohibit it in their copyright notices. The very existence of character readers, however, invites copyright abuse unless reasonable legitimate uses are provided for. Until the legal thickets created by the technology are explored and mapped by the courts, the technology is unlikely to develop to its full potential.—Steve

Keeping In Touch

Dear Steve:

I have been a professional computer programmer for some years now, specializing in graphics-oriented projects on various microcomputers (such as the Apple II and the IBM PC XT). I was forced to leave computer programming some months ago, and I have decided to keep in touch with the technology by subscribing to several journals. My subscription to BYTE is in the mail now, but I am looking for more magazines, especially those concentrating on languages, compilers, and graphics software. I would be grateful if you could name some other sources of information for me.

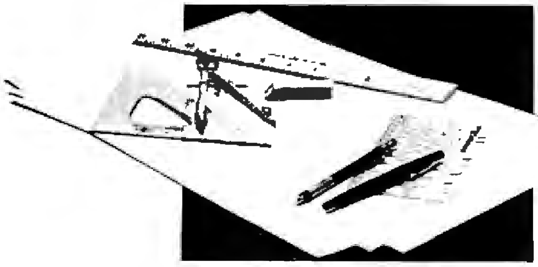
I am also interested in compilers and their associated libraries—mainly C libraries. Though I have some source code (BDS C and Aztec C), it is far from sufficient. Can you name some books or compiler source listings that I could obtain?

Israel Kehat
Haifa, Israel

continued

AutoSketch™

A Resource to Draw Upon

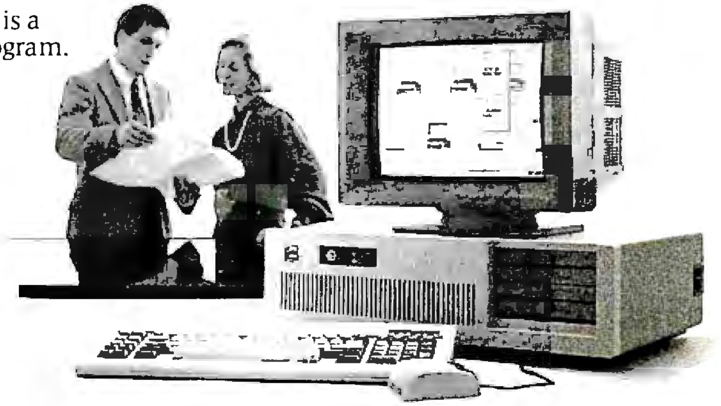


To get any job done, you need the right tools. Ideally, they should be extensions of your talents, freeing you to do what you do best. And speed, precision, flexibility, and consistency are always top priorities, no matter what the job.

If communicating with drawings is part of your job, AutoSketch should be one of your resources.

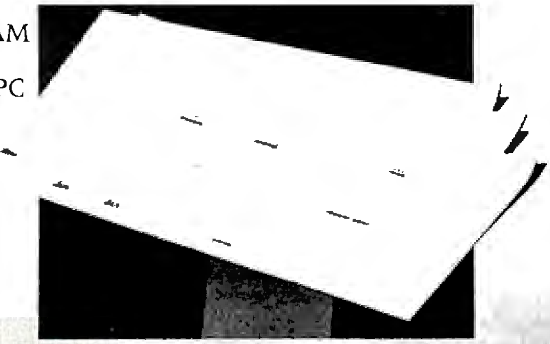
AutoSketch from Autodesk, the developers of AutoCAD,® is the precision drawing tool for professional use. It's fast, powerful, and simple to learn. The price is right, too.

With AutoSketch and your personal computer, you'll enter the world of computer-aided drawing with ease. You may never have designed with a PC before, and you may think it's bound to be complicated and time-consuming. Surprise! With AutoSketch, you'll probably be up and running in about an hour.



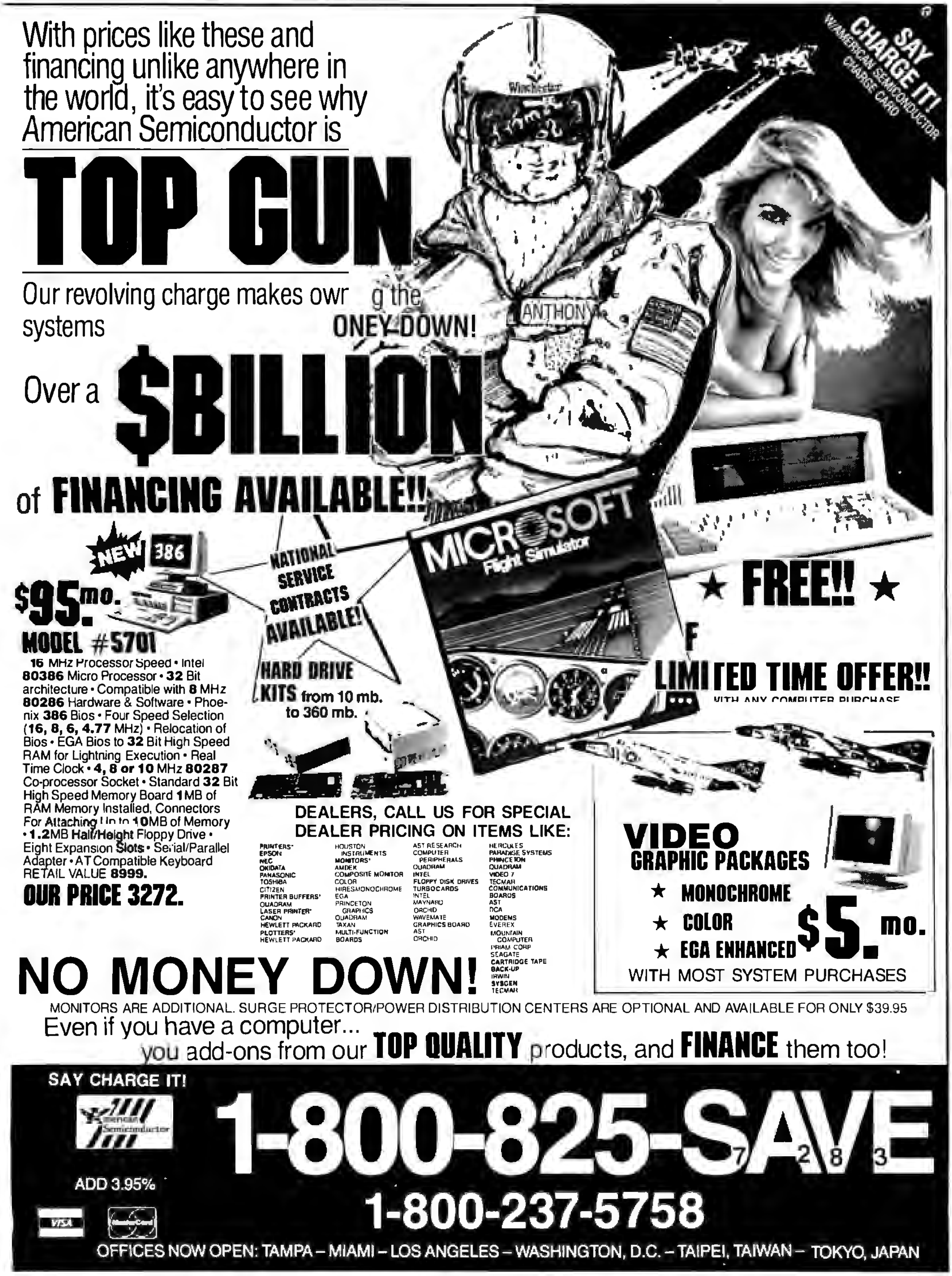
Despite its ease of use, AutoSketch is a full-function, object-oriented CAD program. Pull-down menus and dialog boxes help you each step of the way. With a click of the mouse, you can draw, then copy, mirror, or move objects, even create symbol libraries. AutoSketch automatically updates measurements whenever you stretch, scale, or rotate dimensioned objects. It even keeps track of everything you do, so that you can delete and restore parts of your drawing as easily as you change your mind, using successive undo or redo commands.

We know you'll be impressed with the professional results. So will your clients and colleagues.



AutoSketch runs on the IBM PC/XT/AT and compatible systems with a minimum of 512K RAM and either color or monochrome display. The standard version is yours for just $79.95. If your PC has an 8087 or 80287 math coprocessor, this version operates about three times faster. The speed-enhanced version for $99.95, requiring the coprocessor, is three times faster still.

Call 800-445-5415 for the name of the AutoSketch Dealer nearest you or more information on supported peripherals.
To order direct with a credit card, call **800-772-9200, ext. 347.**



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MODEL #5701
16 MHz Processor Speed • Intel 80386 Micro Processor • 32 Bit architecture • Compatible with 8 MHz 80286 Hardware & Software • Phoenix 386 Bios • Four Speed Selection (16, 8, 6, 4.77 MHz) • Relocation of Bios • EGA Bios to 32 Bit High Speed RAM for Lightning Execution • Real Time Clock • 4, 8 or 10 MHz 80287 Co-processor Socket • Standard 32 Bit High Speed Memory Board 1MB of RAM Memory Installed, Connectors For Attaching Up to 10MB of Memory • 1.2MB Half/Height Floppy Drive • Eight Expansion Slots • Serial/Parallel Adapter • AT Compatible Keyboard
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This organization puts out a quarterly newletter ($25 per year overseas). It also has a 124-disk public domain library; disks are available to members for $8 each (plus a 30 percent overseas shipping charge).—Steve

CIRCUIT CELLAR FEEDBACK

Image Scanning

Dear Steve:

Please help a nonengineer tackle a major project. I have an application that requires scanning a large (we're talking *large*) number of drawings as image data using a Canon IX-12 scanner, an IBM XT, and Dr. Halo software. The resolution of the scanner is wonderful, but it is slow—particularly if you have to scan, say, 10,000 images.

Is there any way to speed up the scanner, perhaps by adding a coprocessor such as the Intel 82786 or TI TM534010 to the IBM PC XT? Will a faster clock speed for the CPU help?

I would like to build a dedicated machine for the scanning, since it is so time-consuming. Could I use a single-board computer with a coprocessor board and Dr. Halo in permanent memory, to do nothing but scan images and save the data to a ½-inch streaming tape drive? If so, can you recommend a good single-board computer?

Finally, where could I find an engineer or hobbyist knowledgeable enough to help me assemble a dedicated unit for a reasonable fee? The working engineers I have found are too involved in company projects to moonlight, and I'm considering trying the electronics engineering department of a local university. Thanks for any help you can give me.

Mike Matthews
Clearwater, FL

Indeed, goosing the performance of your scanner hardware is a big project. I'm not sure you're looking in the right place, though, because the numbers don't hold up to close scrutiny.

Suppose the scanner works at a resolution of 100 dots per inch (some are higher, some are lower; insert your numbers and see). For an 8½- by 11-inch image, you've got about a million dots—or just shy of 128K bytes of raw data. That's also assuming that the images are binary: Each dot is either on or off. For either 16 gray levels or 200 dpi, just multiply everything by 4 (multiply by 16 for both). It's a lot of data!

The raw bus transfer rate for an AT is about 1 megabyte per second, so it should take perhaps a second or two (considering overhead) to get the raw data into memory. A stock PC will be about three or four times slower, so it might take 5 to 10 seconds.

The Canon IX-12 uses a serial interface to communicate with the PC. I don't know what that special interface card is set for, but let's assume that it's 38.4K bits per second. That's about 3840 bytes per second, so that 128K-byte image takes about half a minute to get into the PC. At 200 dpi it's up to maybe two minutes or so. Obviously, the PC hardware isn't the limiting factor.

The software that mashes the images into compressed picture format may be a trifle poky, depending on what it's doing and how it's designed and coded. I suspect that you could improve it somewhat, but unless you're waiting for more than about five minutes per picture it's probably not worth the effort and expense.

You might want to look into other scanners that use a direct parallel attachment

continued

rather than a serial link. Check the September 30, 1986 issue of PC Magazine *for a review of several scanners (including the IX-12). I suspect that you'll find it's a lot cheaper to buy another scanner (and the accompanying software to drive it) than to build your own custom scanner. Look at it another way: The price range for scanners tops out at a few hundred thousand dollars. You can get a lot of clever design for that much money—and it's better to get something that's supported by a real manufacturer than a computer science project.* —Steve

Remote-Controlled Woodstove

Dear Steve:

This is not a computer problem per se, but as a BYTE subscriber and a regular reader of your column I know of your interest in remote-control devices.

I am looking for a remote switch that can be activated by a Touchtone signal or other signal device from the caller's phone (similar to a remote-controlled telephone answering machine). I am renovating a vacation home and I plan to use it in the winter on an irregular basis. If I could turn on the boiler from 150 miles away by telephone, I would arrive at a warm house. (I have to drain the water supply when I leave, but the heating system has antifreeze.)

If such a device exists, perhaps you could point me in its direction. Or perhaps you might design one as a project. Such a remote switch would have many uses other than the one I have in mind.

John Penney
New York, NY

A device such as you are seeking which allows remote-control functions over the telephone is available as part of the home control system made by the X-10 Corporation (formerly BSR). These components are available from numerous sources, including Sears, Radio Shack, and Heathkit. The exact item you want is called the Telephone Responder. —Steve

Remember Cassette Ports?

Dear Steve:

I have what is perhaps an unusual request: I am looking for an inexpensive way to add a cassette port to PC and AT clones.

In my office, we use several laptop computers (clones of the Tandy 100) when traveling. We use portable cassette recorders for storing completed documents to free up memory on the laptops. Since we do not need to access the documents again until we return to the home office and transfer them to the PC or AT clones, this is much more cost-effective

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than portable disk drives.

It would be nice, however, if we could attach a cassette player to one of the clones through a cassette port so we would not have to reload the documents onto the portables and then transfer them to PC clones through a null modem.

I realize cassette players are an outdated technology, but they are the cheapest way we have found to expand our storage capacity on the road. Any ideas where we might find an inexpensive cassette port on a board or in a kit?

Andrew P. Morriss
Hereford, TX

Ironically, genuine IBM PCs have a cassette tape interface built right in. IBM figured that there would be a market for low-cost PCs, so the cassette port was its attempt to support low-cost storage. Nowadays the clones leave it out to save money: Nothing is sacred anymore.

I thumbed through several sources for oddball PC gadgetry and drew a complete blank, so I don't think there's an off-the-shelf interface for you. The problem is that there is no standard definition for the signals on the tape; thus, there's no way of telling what the beeps and boops really mean.

For example, old Digital Group systems had an audiotape interface that could store several files on one tape and do a limited amount of searching if you were willing to push the buttons. But those tapes couldn't be interchanged with any other system because the header and file information wasn't compatible with anyone else's.

I suspect you could get the specifications on the tape file format from a hard-core Tandy 100 users group, then contract with an engineer/programmer to build a widget for your PCs and write some code to read the files, but it would probably wind up being so expensive that it wouldn't be worth it.

Sorry I couldn't be of more help.
—Steve

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, in 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 your knowledge of 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.
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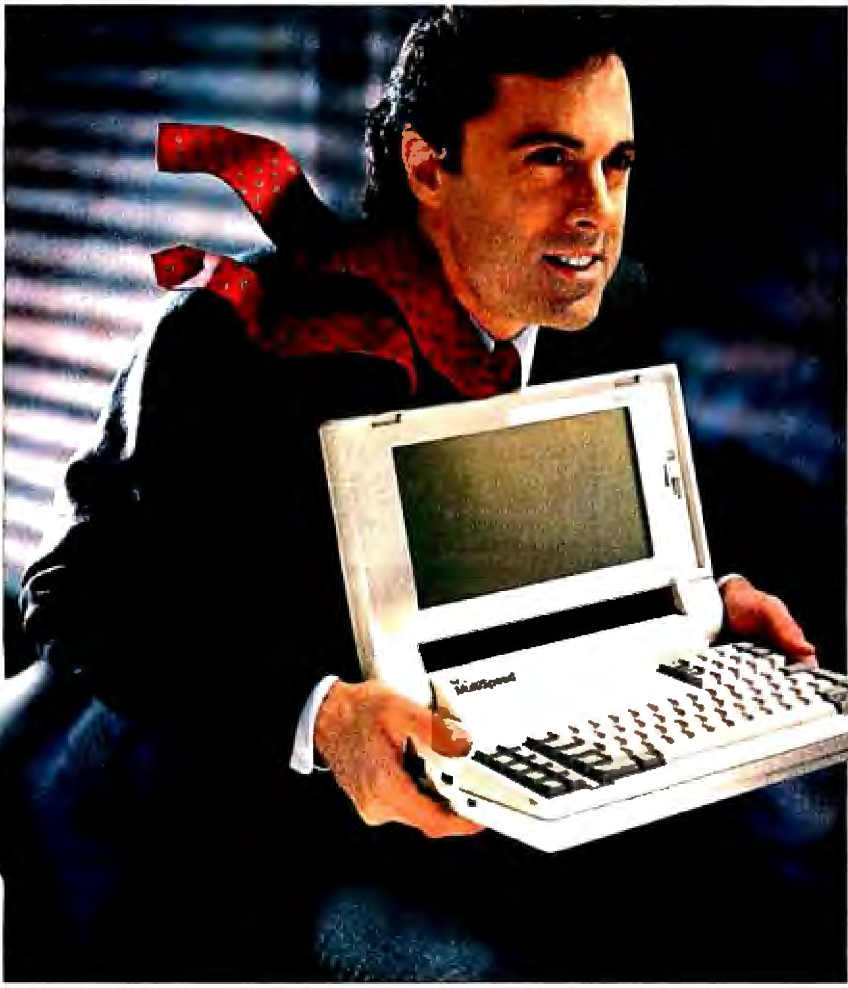

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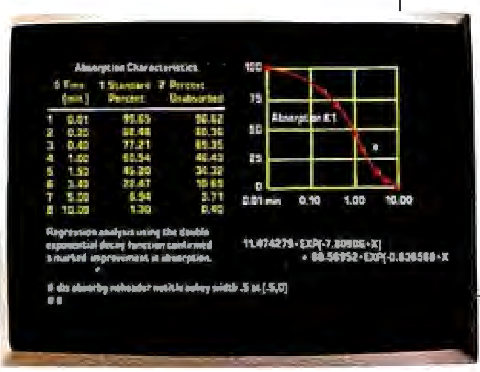

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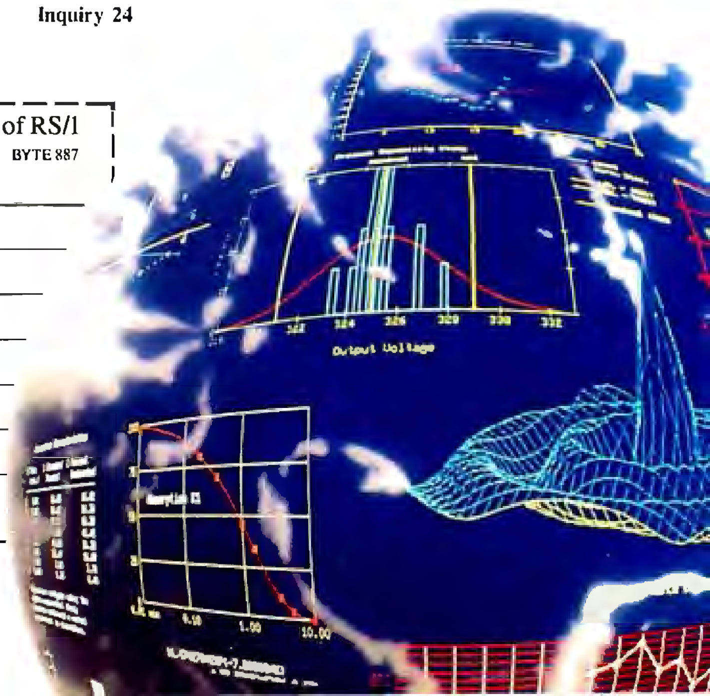

PROLOG PROGRAMMING FOR ARTIFICIAL INTELLIGENCE
Ivan Bratko
Addison-Wesley
Reading, MA: 1986
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423 pages, $25.95

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Martin A. Fischler and Oscar Firschein
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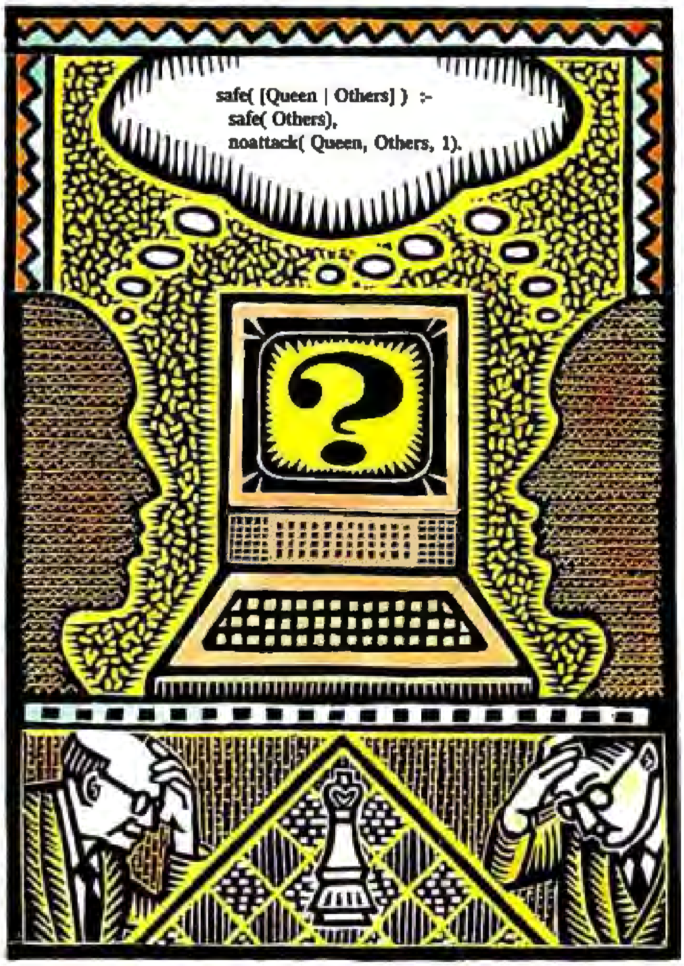

PROLOG PROGRAMMING FOR ARTIFICIAL INTELLIGENCE
Reviewed by Alex Lane

The title of Ivan Bratko's book—*Prolog Programming for Artificial Intelligence*—gives the impression of an advanced text that's tightly focused on AI. For that reason, it may be overlooked by Prolog beginners as they search for a good introductory text on the language. However, the author has arranged his material in such a way that you don't need knowledge of AI or Prolog—or even of programming—to read the book profitably. Bratko goes so far as to suggest that "plentiful experience" with conventional procedural languages like Pascal might even hinder the learning process.

The text is divided into two parts of approximately equal size, and the Edinburgh syntax (also called the DEC-10 syntax) is used throughout the book. Part one introduces the Prolog language with a general overview and examination of the language's syntax. Discussions grow more complex with the subsequent introduction of lists, operators, and arithmetic operations. These concepts then get a workout in a chapter devoted to short example programs ranging from the retrieval of information from a Prolog database to simulation of a nondeterministic finite automaton (see figure 1).

Part two covers Prolog applications in AI, particularly, heuristic search and problem solving, expert systems, game playing, and pattern-directed systems.

Numerous Solutions Lay Groundwork

Bratko's approach to solving the classic eight-queens problem—placing eight queens on a chessboard such that no two of them attack each other—particularly impressed me. While most authors would simply work out a solution and then move on to other things, Bratko persists and solves the beast three more times, using different approaches and data representations. In this way, he quietly underscores Prolog's flexibility in accommodating various problem-solving approaches and, as a side effect, assails the theory that preaches that there is only one correct solution to a problem.

Bratko devotes additional chapters in the early part of the book to the control of Prolog's backtracking mechanism (including the cut and fail predicates), to term and character (I/O), and to a core of built-in procedures commonly used in Prolog programming.

Part one closes with an interlude devoted to Prolog programming style and technique, including an extensive discussion of program efficiency. The chapters in part one follow each other logically and provide a solid grounding in the Prolog language.

AI Applications

The second part of the book covers specific Prolog AI applications, beginning with operations on data structures and tree representations. One example of alternative representations of lists strongly emphasizes the symbolic nature of Prolog programming, although I felt the author did not develop the following phrase as well as he might have: "It is important to notice that the special Prolog notation for lists and the alternative representations amount essentially to the same representation if properly abstracted." Nonetheless, Bratko proceeds to present a good basic text on AI with a strong Prolog flavor.

continued

Illustration by Beth Krommes

For instance, he begins simply by giving his attention to depth-first and breadth-first search (see figure 2) and then refines these techniques by adding the best-first heuristic, which takes up the whole of Chapter 12. The eight-tile problem is solved twice, both with and without best-first search, again building on previously discussed material. Another chapter considers AND/OR graphs with subsequent application of the best-first heuristic there, too.

Moving from basic concepts to a more sophisticated area, Bratko turns to expert systems. By showing how Prolog can be used to represent IF . . . THEN rules (also called production rules), he gives examples from real expert systems and builds a small knowledge base for identifying animals. He then methodically develops an expert-system shell that includes an explanation facility to answer "why" and "how" questions from the user. The shell falls short of dealing with uncertainty, although the subject is discussed at the end of the chapter.

Chess and Go

Games are the next subject of inquiry, and here the author considers techniques for playing two-person, perfect-information

continued

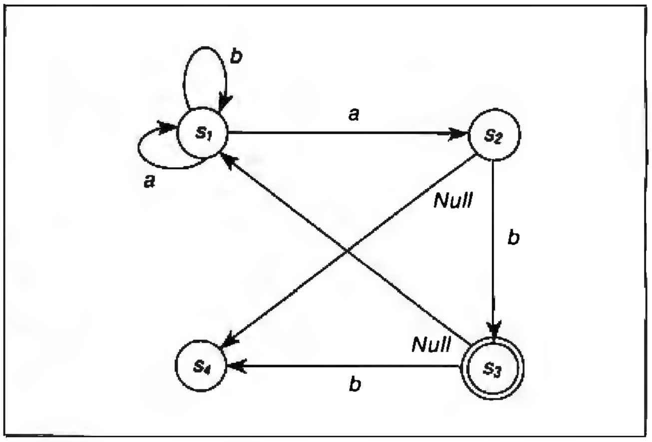

Figure 1: *A redrawn example of an automaton from* Prolog Programming for Artificial Intelligence *by Ivan Bratko. Reprinted with permission from Addison-Wesley Publishing Company Inc.*

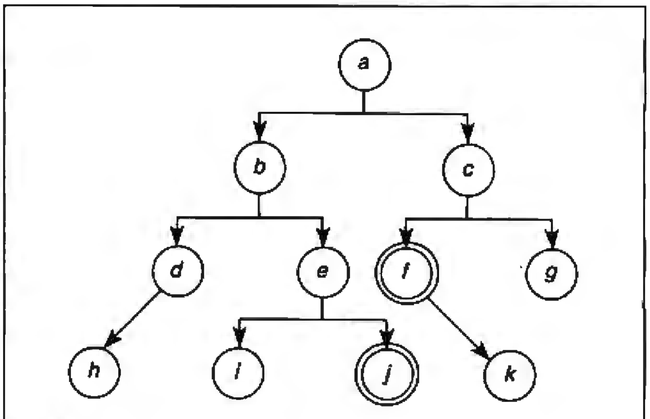

Figure 2: *An example of the breadth-first search strategy showing nodes closest to start node a. The f and j are goal nodes. Redrawn from Ivan Bratko's* Prolog Programming in Artificial Intelligence. *Reprinted with permission from Addison-Wesley Publishing Company Inc.*

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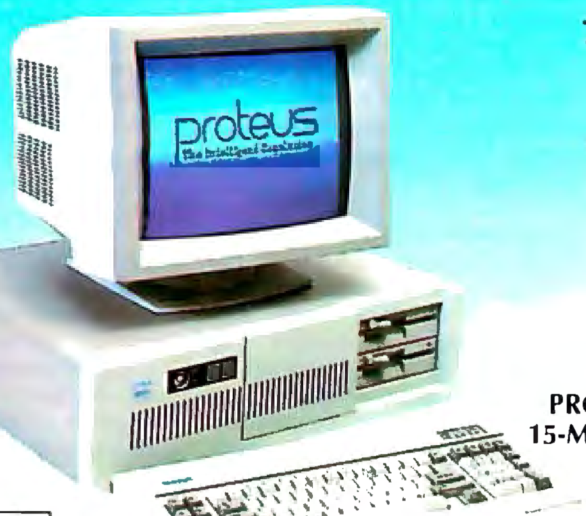

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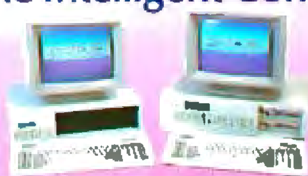

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games (e.g., chess, checkers, and go). Although a classical AI approach to playing these games entails implementing the minimax algorithm and alpha-beta pruning, Bratko merely describes these techniques and gives examples. He then considers the introduction of pattern knowledge into the game by means of advice. The chess theme recurs here as Bratko, who has published several international papers on chess and AI, presents the reader with an Advice language interpreter and an Advice program for playing a king-and-rook versus king ending. Knowing a little about chess helps to wade through this example.

A final approach covers pattern-directed programming, which is well-suited to Prolog because it can be considered a pattern-directed language. During the course of this brief discussion, Bratko develops a simple theorem prover that uses resolution.

Assessment—Pro and Con

I found much to like in this book. I appreciated the organization of material and benefited from the summaries and exercises found at the end of each topic. Answers to selected exercises appear conveniently in the back of the book, before the index. I also valued having all Prolog expressions displayed in distinctive boldface type, and the book's style of both alternating lines of Prolog code with explanatory text and separately presenting the same code as a block in a single figure was helpful. The numerous examples—the first of which appears smack on the first page—helped to clarify rough spots in my own understanding.

On the minus side, there were times when Bratko's methodical approach seemed too slow. Typing in the code for the Advice language interpreter and the chess endgame Advice files, for example, had me flipping around to three different places in the book. However, considering the pedagogic nature of the book, its methodical approach is more an asset than a liability.

It is hard for me to imagine anyone with an interest in either AI or Prolog not deriving significant benefit from reading *Prolog Programming for Artificial Intelligence.* For those familiar with Prolog but not AI, it presents AI concepts in concrete form; for AI researchers unfamiliar with Prolog, it provides an entry to a second point of view of the AI world. I believe this will be a widely used book.

Alex Lane (P.O. Box 4850, Jacksonville, FL 32201) is a registered professional engineer with a strong interest in AI. He is the moderator of the Prolog conference on BIX.

USING TURBO PROLOG and ADVANCED TURBO PROLOG

Reviewed by Namir Clement Shammas

Using Turbo Prolog by Phillip R. Robinson introduces readers to the Turbo Prolog environment and implementation. Some of the book's strong points include a clear and friendly writing style; a considerate, slow pace (for the novice); and numerous screen images. The author uses headline titles that add to the clarity of his style, enabling the reader to follow changes in the subtopics.

In the first of three main sections, Robinson focuses on the Turbo Prolog environment by using screen images. He leads you through an adequate tour of the environment options and the text editor.

Robinson discusses programming concepts of Prolog and Turbo Prolog in the second part of the book. I enjoyed this discussion and examples of backtracking, list handling, and the cut and fail predicates. Several versions of a Turbo Prolog program

continued

are presented (one without the cut predicate, and the others with cut placed in different locations), followed by an explanation of what each version did when it ran. Despite its clear style and the consistent use of screen images, the book lacks diagrams and illustrations. For example, Robinson explains backtracking in Prolog, yet he includes no diagrams to accompany the explanation. This is the only weak point I found in the book.

More Turbo Prolog predefined predicates for console I/O, file I/O, graphics, and windowing are found in the third section. Robinson presents advanced Turbo Prolog programming techniques in a separate chapter. He is relatively brief and seems to purposely avoid hitting the reader with a stream of advanced information. In addition, he includes a chapter for the GeoBase expert system included in the Borland language package.

Using Turbo Prolog is a book well-suited for the curious and for the student of Turbo Prolog. Its strength is in its slow pace (many authors are tempted to accelerate their pace) accompanied by screen images, making it worth reading even before obtaining a Turbo Prolog system. While hands-on experience is of vital importance, *Using Turbo Prolog* succeeds in offering the next best way of being introduced to the language.

ADVANCED TURBO PROLOG

Advanced Turbo Prolog does not pick up where *Using Turbo Prolog* left off, as readers might hope. Instead, it assumes you know how to use Turbo Prolog; programming experience with Turbo Prolog is a prerequisite for reading this book. Herbert Schildt has written previously on C, Pascal, and Modula-2. This book is a collection of nine independent chapters, each focusing on one area of applying Prolog in general and Turbo Prolog in particular. The topics Schildt covers are solution search, expert systems, natural language processing, vision and pattern recognition, robotics, machine learning, and appearing human.

Schildt presents the foundation of many topics and gives a brief historic background mentioning the pioneers of their fields. Using simple diagrams and without showering you with complex equations or notations, Schildt offers the alternate methods. He also points out their strengths, weaknesses, and preference by AI-application authors. I find this type of presentation most refreshing and highly informative.

In contrast to Robinson's style, Schildt uses figures and diagrams—but no screen images. The book contains many Turbo Prolog listings accompanied by adequate explanations on how the programs or highlighted portions work. The listings are clear and contain a good number of comments.

I was a bit disappointed that the author did not touch on the topic of symbolic math and calculus, since this is a specialty of AI languages.

The discussions for the solution searches using Turbo Prolog were enjoyable. Schildt demonstrates how Prolog uses its internal database and sophisticated backtracking ability in solving a flight-scheduling problem. The search methods include depth-first (how Prolog normally works), breadth-first, hill-climbing, and least-cost. Likewise, I found the author's tackling of the inference engines in expert systems informative. Schildt mentions three alternate methods used in constructing an inference engine: forward chaining, backward chaining, and rule value. He selects the first method to develop a general-purpose expert system. It is interesting to note that other books have been published that demonstrate similar systems written in Pascal, Modula-2, and even BASIC.

The topic of natural language processing is among the most important and wide-reaching in the book. Schildt quickly and appropriately lets you know that NLP is a complex subject. He uses limited vocabulary and syntax as the basis to demonstrate three types of NLP parsers: state-machine, context-free recur-

continued

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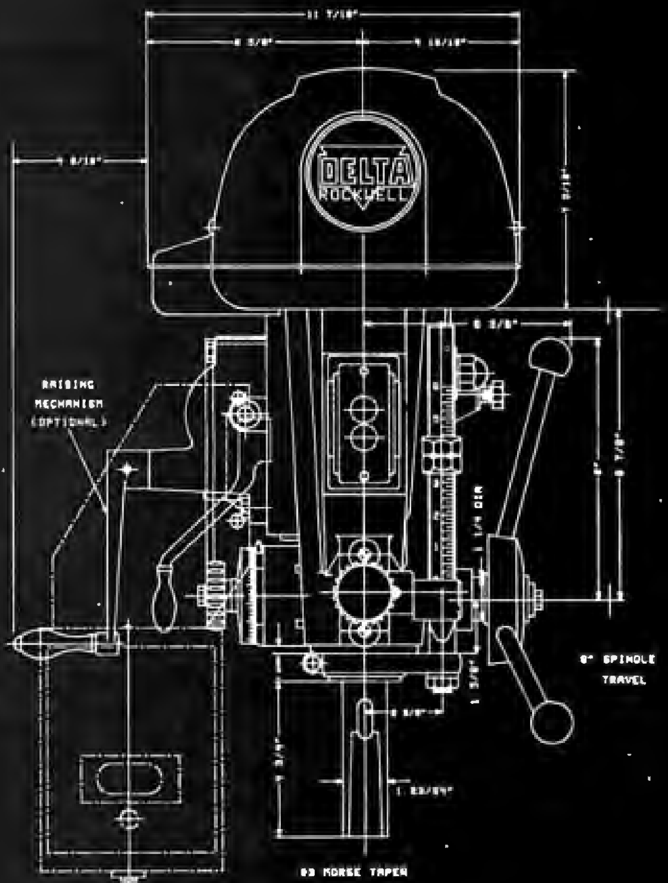

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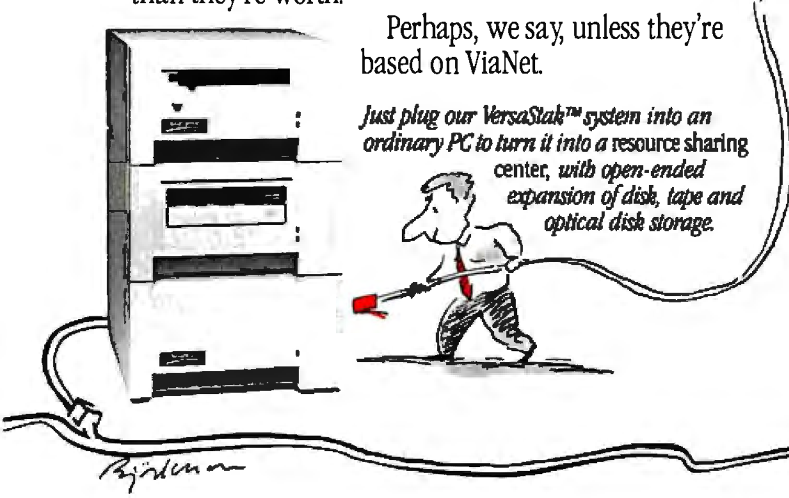

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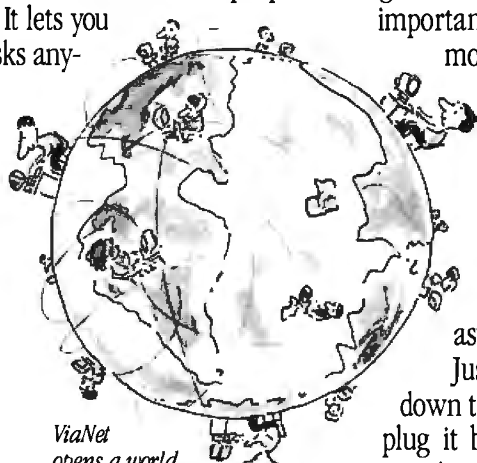

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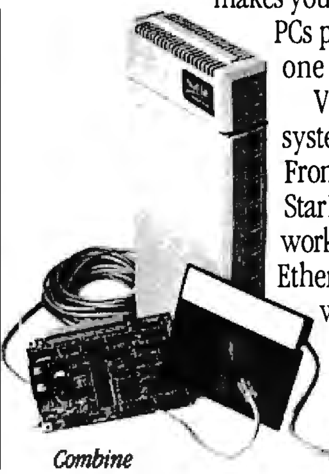

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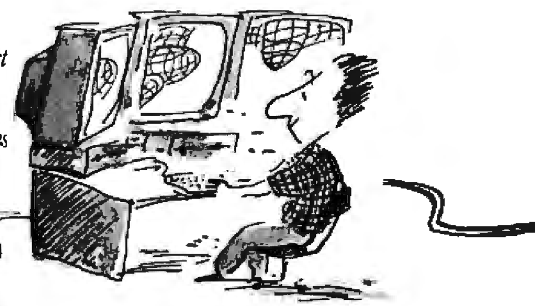

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sive-descent, and noise-disposal.

Using the simple sentence "The child runs quickly to the house" (and its variations), Schildt deals with the first two parser types. The noise-disposal parser uses a tiny set of commands similar to that of popular database languages. Here, he tackles the topic of using NLP command parsers to make a software application perform a specific task. However, Schildt does not cover this area extensively. Neither does he take full advantage of his multilanguage programming skills or the ability of Turbo Prolog to interface with other languages to write a smart NLP command shell. Such a shell has a Prolog program analyzing the user's English-language commands and loading an appropriate overlay written in another language, such as C. The lack of such an NLP shell is a real loss.

While Robinson offers a solid introduction to Turbo Prolog, Schildt's *Advanced Turbo Prolog* offers a background for the topics it covers and many examples for implementing Turbo Prolog. Schildt's listings could become the nucleus of your own library of Prolog toolboxes.

Namir Clement Shammas (4814 Mill Park Court, Glen Allen, VA 23060) is a columnist in several microcomputer magazines and editor of three language newsletters.

INTELLIGENCE: THE EYE, THE BRAIN, AND THE COMPUTER

Reviewed by George Beinhorn

Given the polarity that exists in AI, a field where scientific objectivity seems to get trampled underfoot more often than in others, *Intelligence: The Eye, the Brain, and the Computer* by Martin A. Fischler and Oscar Firschein is a welcome arrival.

The controversy is spawned by the attempt to make machines think, see, and act like human beings. Some AI enthusiasts claim that human intelligence can eventually be reduced to its low-level, machine-like, on/off logical components and reconstructed in computer software.

These proponents battle with those who claim that higher-level human expert judgment draws on abilities that transcend mere logic and can't be learned by or emulated on today's computing machinery. Those representative of this latter group include Joseph Weizenbaum, author of *Computer Power and Human Reason* (W. H. Freeman, 1976), and Hubert L. Dreyfus and Stuart E. Dreyfus, authors of *Mind Over Machine* (Free Press, 1986). [Editor's note: Mind Over Machine *was reviewed in the August 1986 BYTE.*]

For Professionals and Laypersons

Martin A. Fischler, program director for perception research at the AI Center of Stanford Research Institute, and Oscar Firschein, staff scientist at the AI Center at SRI, provide a rigorous review of current research findings in fields closely related to AI. Their book serves as a reference from which both the visionary claims of AI adherents and the humanistic alarmism of its foes can be judged.

Fischler and Firschein cover human intelligence, the capabilities of the brain and computers, problems in machine representation of knowledge, human and machine methods of reasoning and problem solving, learning (by humans and computers), language and communication, expert systems and knowledge-based systems, and human and computer perception (vision).

This book is by no means an attempt to popularize AI or explain its methods to the general reader; rather, it is an "an intellectual journey into the domain of human and machine intelli-

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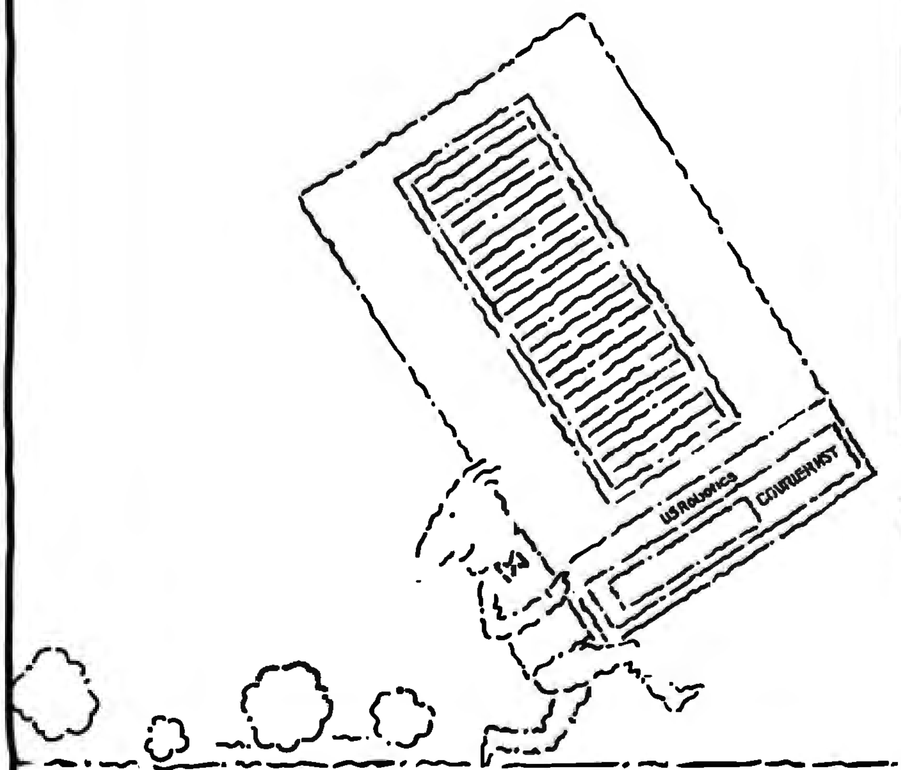

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gence." It is said to provide "*Scientific American* level readers" and AI experts with an introduction to psychological research on human intelligence, the cognitive and perceptual abilities of humans and machines, and the representations used by humanity and machine to attain intelligent behavior.

A Certain Credibility

At no point do the authors succumb to the temptation to take sides in the debate over the prospects for AI. The two questions they adhere to are: What is known in fields that affect AI? and What are the prospects for applying present knowledge about intelligence and computers to make computers emulate certain human abilities?

While the book's scientific compendium makes for reading that's more reminiscent of a textbook than an introduction for general readers, this book will undoubtedly be useful for AI programmers and researchers who may be uncomfortably aware of gaps in their knowledge of significantly related fields.

There's no doubting Fischler and Firschein's interest in commenting on ultimate, visionary questions, however. Early on, they introduce the basic questions regarding AI's ultimate limits: Can humans create a machine more intelligent than themselves? Are there components of humanity's intelligence that cannot be found in any animal or duplicated in a machine? Can all intelligent behavior be duplicated by the current approach to AI, namely, by decomposing a given problem into a sequence of simple tasks or subproblems that can be precisely stated and solved? The authors return frequently to these basic themes, and their modus operandi of first summarizing present knowledge, then drawing consistent and carefully qualified conclusions, lends their speculations a credibility conspicuously lacking in more biased books on AI.

Philosophical Speculation

The larger concerns disappear for long stretches, however, replaced by Fischler and Firschein's minute examination of subdomains—their review of knowledge representations used in AI research, being one example. But they appear often enough to provide a tenuous continuity. For instance, in the summary for the chapter on representation of knowledge, one of the most abstract in the book, they manage to refocus on the wider context by discussing "the extent to which the complexities of the world can be reduced to a manageable set of symbolic relations susceptible to logical analysis," drawing on philosophical speculations in the process.

By aiming their book at two different audiences—the AI researcher and the curious scientific reader—the authors give themselves a difficult organizational task, which they handle adeptly by separating technically complex matter (e.g., various AI problems as coded in LISP, Prolog, and OPS-5) into chapter appendixes and text boxes. The illustrations are good.

General and expert readers alike will of course be eager to learn Fischler and Firschein's conclusions regarding the basic question of AI: To what extent is it possible to model intelligence as an information-processing activity that can be carried out by a machine? In presenting their deductions, they use the paradigm of an intelligent robot, "because such a device would have to draw on the entire range of intelligent capabilities, from reasoning to language to vision . . . ." They then draw up a list of essential conditions for intelligent robotic behavior, with point-by-point comparison of theoretical possibilities and actual accomplishments in AI.

Questions Answered

Fischler and Firschein's extremely lucid epilogue can be summarized by their following conclusions to some rhetorical ques-

continued

tions I have had: Can a machine truly understand? The authors address the potential importance of consciousness in a robotic device and the equally puzzling issue of subjective understanding. They ask "what have we lost by implementing the appearance, but not the substance, of conscious awareness?," concluding that the answer remains as intellectually complex and elusive as the nature of the connections between human beings and their world.

Can a machine take a role in society as if it were a person? The authors incline to accepting Joseph Weizenbaum's argument in *Computer Power and Human Reason* that true understanding can be gained only from experiencing the world with the reactive equipment of a human body and brain. But they suggest, "If we change the question . . . to: Can a machine play a useful role in society?, rather than requiring the machine to function as a person, then the strict requirements for deep understanding of the society indicated by Weizenbaum can be relaxed." They are careful to cite Weizenbaum's warnings regarding devices that emulate intelligence in ways that could mislead humans into placing too much faith in them.

Another question posed by the book: "How can a computer focus its attention on just those aspects of a given problem that are relevant to its solution?" This problem, commonly known as the "frame problem," has no easy solution, and virtually no progress has been made in extending AI software's abilities from limited domains to those of a hypothetical autonomous robot that could "think before it leaps."

In answer to whether intelligent behavior is decomposable, Fischler and Firschein admittedly don't know, and they refer again to the pragmatic distinction between highly intelligent, human-like behavior and "useful devices based on reductionist principles."

Concerning the several theories of the relationship between language and thought, the authors draw no firm conclusions. They further speculate on what might be gained from research on the relationship between thought and image processing.

Fischler and Firschein again give no firm conclusions to the query, What is the nature of representation used by the brain? Instead, they cite the speculations of several leading researchers, reminding the reader that progress in this area of AI has been very slow.

Issues for Academic Research

Fischler and Firschein conclude that, at this stage in its development, the prospects for AI are unknown. Their view is summarized in a statement by AI researcher Terry Winograd, reproduced in the book, that encapsulates the present state of AI:

"As a dream, there is a unified (if ill-defined) goal for duplicating human intelligence in its entirety. As a technology, there is a fairly coherent body of techniques that distinguish the field from others in computer science. In the end, this technology base will continue to be a unified area of study with its special methodology. We will recognize that it is not coextensive with the dream, but it is only one (possibly small) piece. . . ."

Readers whose main interest is in practical, business-related applications of AI technology (e.g., expert systems) will find little of interest in this book, which is aimed rather at academics, students, and others concerned with fundamental issues in AI research.

Though the authors nowhere claim to have broken new ground in AI research, their penetrating overview of relevant fields is both unique and refreshing, and it will undoubtedly be welcomed by anyone seriously interested in the relative abilities of the brain and digital computers. ■

George Beinhorn (14618 Tyler Foote Rd., Nevada City, CA 95959) is a freelance technical editor and writer.

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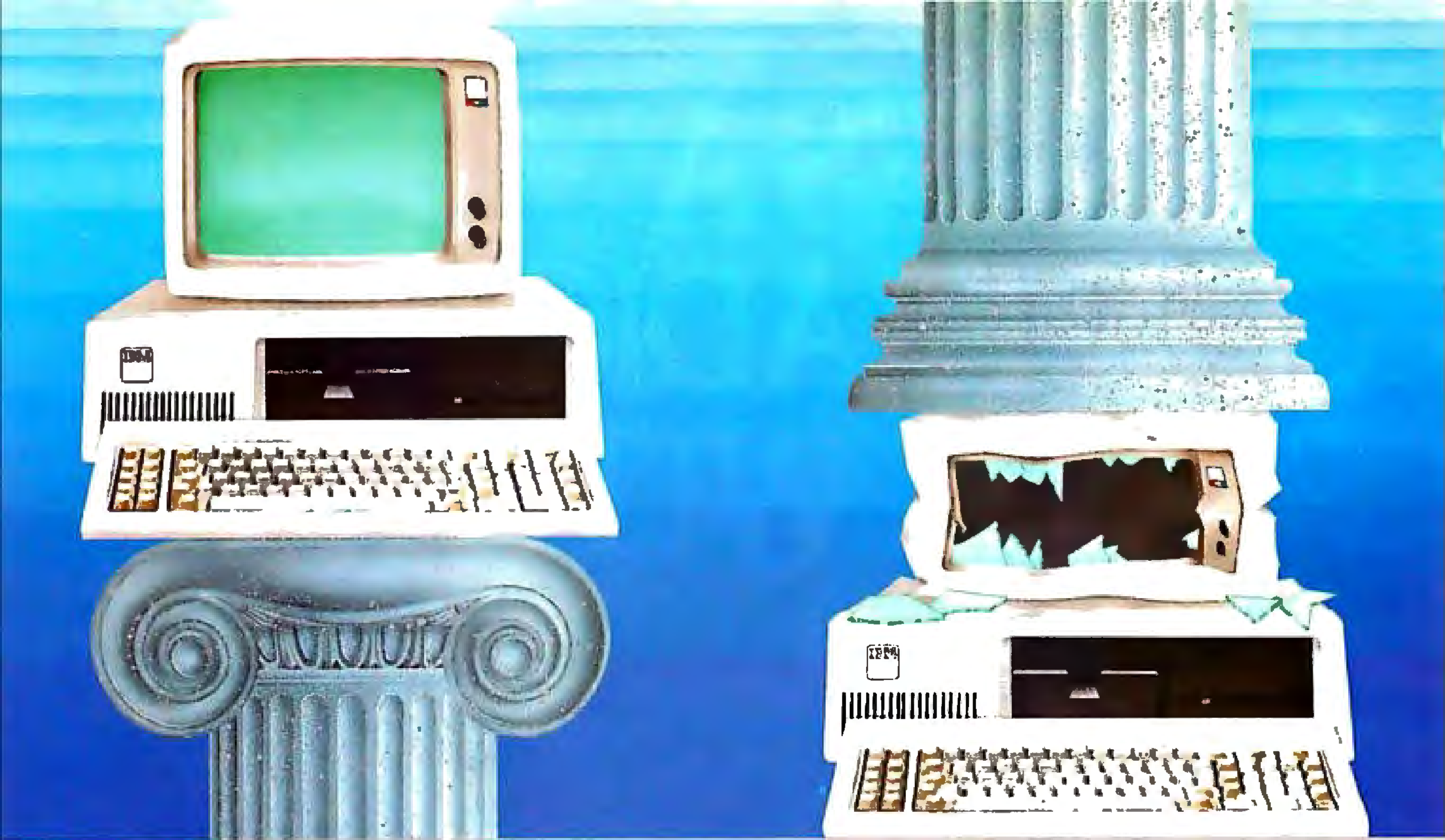

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PC MAGAZINE
The Best of 1986

Steve Ciarcia

Under the Covers

The new IBM Micro Channel as seen from inside the PS/2 Model 50

What would you say if someone asked you to pull the covers off a new IBM Personal System/2 Model 50, crawl around inside, and report on what it's like in there? Even I couldn't resist, though I've been known to berate IBM for a thing or two. I succumbed to curiosity and agreed when BYTE asked me to look at the PS/2's Micro Channel from the view of an engineer, one who needs to know more than what's given in the typical glossy descriptions on the new box. I didn't want a single opinion to dominate the conclusions, so I formed a team that included members of the Circuit Cellar research staff. Together we designed our tests, performed them, and came to our conclusions. Our approach differed from that of usual reviewers; ours was an engineering perspective. We were more interested in whether the Micro Channel would be useful for intelligent I/O devices and data acquisition than whether and how fast Lotus 1-2-3 would run.

We evaluated a Model 50 with an 8513 color display using the *PS/2 Hardware Technical Reference Manual* to find some of the information and an oscilloscope to dig out the rest. Unfortunately, the machine we received had no expansion boards other than the hard disk controller, so we couldn't test some of its more involved features.

We wrote some assembler routines to check out interrupt-response times and direct memory address (DMA) loading and compared the 10-MHz Model 50's results with those of an 8-MHz PC AT. Please accept this for what it is: our first look at a new machine.

Untouched by Human Hands

The first impression you get when you pull the cover off the Model 50 is that the insides have been untouched by human hands (see photo 1). Everything slides into place, snap-locks without screws, and connects without wires. (More details of disassembly are covered in "The IBM PS/2 Model 50" in the July BYTE.)

In the disassembled system unit (see photo 2), the motherboard uses surface-mount ICs for everything except the EPROMs, keyboard controller, VLSI processors, and several gate arrays. You won't be able to fix this one with standard TTL parts; they just won't fit. Notice the shiny aluminum component packages produced by IBM. Cloners take note: These won't be easy to crack.

There were a few engineering-change wires on the top of the motherboard. Given its complexity and the fact that it's at the 01 revision level, that's not bad at all. It always takes a few passes to get it right.

Distribution of Power

The motherboard has internal power and ground planes to carry the power-supply voltages. The power connector on the edge of the board devotes 24 of its 50 pins to ground and 17 more to +5 volts. The sticker on the power supply states that the current is limited to 760 milliamperes per pin for +5 volts, which works out to about 13 amps total.

The PS/2 power supply will work with no load although the regulation is poor, and, not surprisingly, the "power good" signal might indicate that the power isn't alright. This is a pleasant change from the original IBM PC power supply, which could be ruined if it was operated below a minimum load, and an improvement over the PC AT's power supply, which requires a dummy load on the unused hard disk power connector.

Each card connector can draw a maximum of 1.6 amps from the +5-volt power supply. The typical current is limited to 1.4 amps, and a set of formulas in the technical reference manual describes precisely how to calculate these values. The logic power supply is regulated to 5 volts, +5 or −4.5 percent, at the connector, just before the actual pins to the card. You can calculate the actual voltage on your card based on the connector-pin resistance and the current through each power pin.

About 25 percent of the card-connector pins are dedicated to power and ground supplies. No signal is more than 0.1 inch from a ground point (either a digital ground or a power supply that's bypassed to ground). The card-design guidelines give specific suggestions to reduce electromagnetic interference (EMI) from high-speed clock and handshaking signals on each card.

EMI Attack

IBM has given a great deal of attention to reducing EMI in the Model 50. (EMI is caused by radio-frequency radiation from electrical equipment. The FCC sets strict standards to limit the intensity of that radiation from computers.) While its case and internal subchassis are both molded plastic, they're sprayed with conductive metal to form a continuous EMI shield. The top cover is metal and has EMI gaskets mating with the case along critical sections. The seal is so good that only two thumbscrews are needed to hold the two

continued

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tightly together.

There is a lock on the case to secure the top cover. Given that the case is plastic, I'm not convinced that this is particularly secure, but it augments the thumbscrews. Unlike the PC AT, the Model 50 has no electrical connection to the lock. It has a keyboard password program, but it's easy enough to defeat: Just remove the battery and let the CMOS RAM forget.

Square metallic grids on the bottom of the motherboard (see photo 3) match up with support posts molded into the bottom of the case. Embedded in each post is a small patch of conductive "fuzz" to ensure a solid electrical connection between the board's ground plane and the case's metallic interior. In addition, the board's ground plane is segmented to isolate the high-speed video and high-current I/O devices from the rest of the logic. The I/O connectors on the back panel are electrically attached to a metal sheet that makes solid contact with the metallic-coated case. The spring fingers ensure contact at many points, regardless of manufacturing tolerances.

A side benefit of EMI control is that it will make it easier to ensure that cards work correctly. A clean power supply, solid signals, and quiet ground connections go a long way toward eliminating those glitches that occur often enough to make you tear your hair out, but not often enough to be tracked down and solved.

The Micro Channel

IBM has ended its practice of supplying schematics of the system hardware, but it is now giving a much more detailed description of the interface between the cards and the system. Although this will make it tough for cloners to duplicate the system, it's a boon for those of us attempting to build cards that actually work.

The Micro Channel isn't compatible with either the PC's or the PC AT's bus, so none of your old boards will fit the new 68-pin connectors. The connectors have pins on 50-mil (0.05-inch) centers and are divided into three parts: an 8-bit section that has 24 address lines, 8 data lines, and most of the controls; a 16-bit extension with 8 more data lines and some additional interrupts; and a video extension that gives access to the onboard video hardware. Only one connector has the video extension. Figure 1 shows the pin-outs for the various sections and gives an idea of the scale involved.

You could omit the 16-bit part of the connector to get an 8-bit version of the Micro Channel. Perhaps this means that IBM will introduce a low-cost PS/2 system. More likely, however, it's simply a holdover from an original design based on the 8088 motherboard. The dimension drawings show that even 8-bit cards need a tab to fit into the 16-bit extension socket; the implication is that IBM will provide no 8-bit sockets in the PS/2 line.

The Micro Channel has a 32-bit bus extension to accommodate the 80386 processor in the PS/2 Model 80. I couldn't get any information on this, but it seems a reasonable way to get a wider data path. The 16-bit (and, presumably, 8-bit) cards should work fine in the wider bus.

The video-extension connector allows one card to take over the motherboard's video circuitry and provide enhanced video output. Those of you who still aren't satisfied with the new standard 640- by 480-pixel by 16-color output should take a look at the new IBM 8514/A: its resolution is 1024 by 768 pixels with 256 colors.

I/O devices now have a full 16-bit address instead of the 10-bit address used in the PC and PC AT. Each card must decode the full address; partial decoding that ignores some high-order bits is not allowed. Those 1024 addresses in the PC and PC AT were pretty much filled up, so having 65,536 addresses to play with in the PS/2 is a definite improvement. Of course, they will fill up soon enough.

In addition to the normal digital wiring, the Micro Channel includes an audio line to a linear power amplifier driving the speaker. This allows any card to generate an analog sound and add it to whatever's already on that line. For example, a modem card can now pipe the phone-line audio to the speaker without suppressing the normal audio beeps and boops from the programs. The quality is low-fidelity, but entirely adequate.

Photo 4 shows the PC AT's combined hard and floppy disk controller above the new Model 50's hard disk controller.

If I May Interrupt. . .

A continuing nuisance in the PC and PC AT buses is the fact that two or more cards can't share interrupt lines. The lines are active high, and the cards pull them up with an active driver. If two cards are trying to pull the same interrupt line in different directions, at least one will lose. This is, in fact, a good way to burn out a bus driver or two: Short them between the power supply and the ground.

The PC and PC AT interrupt lines are also edge-triggered, so you get an interrupt when the line goes from low to high. Unfortunately, it's easy to miss an interrupt if you have interrupts masked off and you reset the interrupt controller at the wrong time.

The PS/2 Micro Channel defines the interrupt lines as level-sensitive and active in the low state. The motherboard includes pull-up resistors for each of the interrupt lines, so a line that's not connected to anything is in an inactive state. Several cards can request an interrupt on any line by pulling it low with an

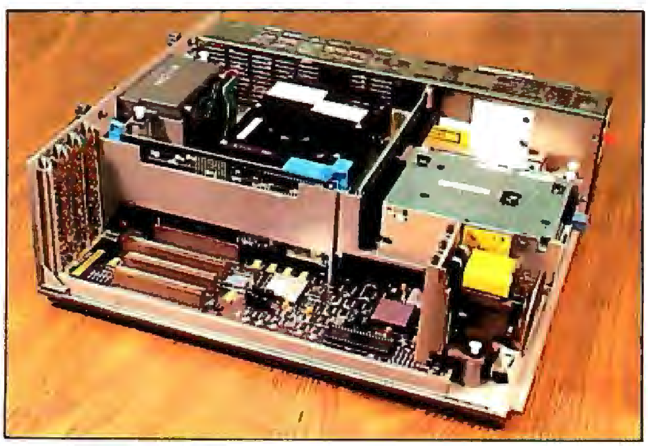

Photo 1: *Overall view of the interior of the Model 50 with its outer case off.*

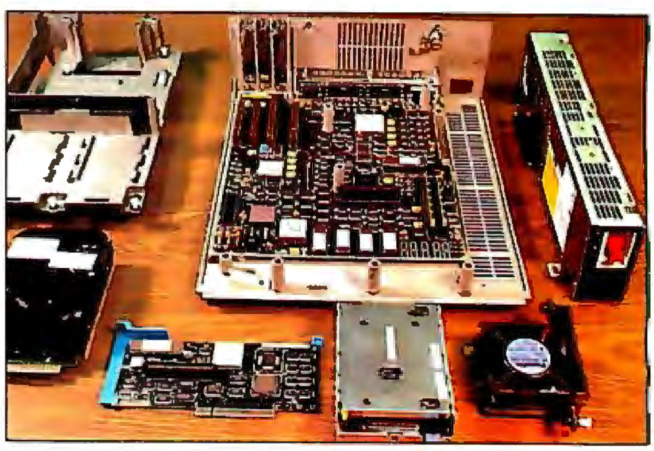

Photo 2: *A disassembled view of the Model 50 with its parts spread out.*

open connector driver (existing cards don't fit in the connectors, so there's no conflict between old and new cards).

Existing PC AT software might try to reprogram the interrupt-controller ICs to the rising edge-triggered mode, so external hardware on the motherboard suppresses those commands. The PS/2 uses the same Intel 8259 Programmable Interrupt Controller as the PC AT, albeit in a new surface-mount package.

Because the PC AT hardware prevents interrupt sharing, hardware interrupt-handler routines don't have to worry about anyone else using their interrupt. The PS/2 technical reference manual states that all interrupt handlers for both hardware and software interrupts on the Model 50 must daisy-chain control along to the next handler in sequence. Only if the handler has processed the interrupt can it break the chain.

Each interrupt vector starts out initialized to 0000:0000 hexadecimal, so the chain of interrupt handlers stops when the last one detects that it's about to pass control to 0000:0000 (not a valid address for an interrupt handler). Software interrupt handlers should indicate the error by returning with the carry-flag set. Hardware interrupt handlers should include a routine that handles stray interrupts.

For example, suppose we set up several serial cards to share interrupt line -IRQ4. When one of them receives a character, it pulls -IRQ4 low and activates the interrupt handler. The handler must check each of the cards to see which one has the character, process the character, reset the interrupt latch on the card, and exit. If another card receives a character, it also pulls -IRQ4 low to indicate that it needs service. Suppose the second card receives the character after the interrupt handler has checked it. When the handler is done, it performs a normal end-of-interrupt but is then restarted because the -IRQ4 line is still active. The handler then checks each card again and extracts the new character from the second card.

But things can get more complicated. Suppose we have a few parallel ports (the PS/2 supports bidirectional parallel ports) connected to some gadgetry, with all the cards sharing -IRQ4 with the serial cards. If the serial interrupt handler finds no serial cards active, it must pass control to the parallel handler. This way, you can daisy-chain many interrupt handlers together, with each one aware only of its own existence and that of the next one in the chain. The same logic applies to software interrupts, which should eliminate a good deal of the confusion caused by software interrupt handlers "swallowing" interrupts and disrupting the chain.

Of course, as more devices share a given interrupt line, it takes more time to figure out which one is presenting the interrupts. For critical applications (are there ever any noncritical applications?), you might want to have only one device on an IRQ line. But now you've got the flexibility to choose how to solve the problem.

Submitting to Arbitration

Although the PC AT bus allows other cards to take control of the bus lines, it isn't easy to have two bus masters sharing control. The Micro Channel includes a set of lines that allows several competing devices to share the address, data, and control lines without conflict. This process is called *bus arbitration*.

Under normal circumstances, the processor will use the Micro Channel for memory and I/O accesses without worrying about other devices. In this case, the processor supplies the address values and synchronizes the control signals, while the devices responding to that address may either accept or generate the data value. The processor is called the bus master because it supplies the control information. The processor must relinquish control of the bus lines when a DMA transfer occurs. The DMA controller supplies both the address and control lines, manages the data transfer, and returns control to the processor when it's done. During the transfer, the DMA controller is a temporary bus master.

The PS/2 extends this notion by requiring any device that wants to use the Micro Channel to submit to arbitration before taking control. Arbitration starts when any device activates the -Preempt line (see figure 1) to request control from the active master. The motherboard includes a circuit called the Central Arbitration Control Point (CACP), which handles the Micro Channel's arbitration functions. When -Preempt becomes active, the CACP sets the Arb/ -Gnt line to Arb to begin a new arbitration cycle.

Each device that wants control of the Micro Channel puts its 4-bit arbitration level (essentially a priority) onto the ARB0 through ARB3 lines. The details are a little tricky, but basically all the devices drive the lines at once and check for mismatches between their data and the resulting value of the common ARB lines. The winning device continues to drive the lines, while the losing devices disable their drivers. As a result, everyone knows who won immediately. The CACP then drives Arb/-Gnt to -Gnt to allow the winner to take control of the Micro Channel.

Devices that transfer data in bursts, like hard disk drives and so forth, can assert the -Burst line to indicate that they will be using the Micro Channel for awhile. However, -Preempt overrides -Burst, and the CACP will terminate the bursting device by starting a new Arb/-Gnt cycle. If the bursting device

continued

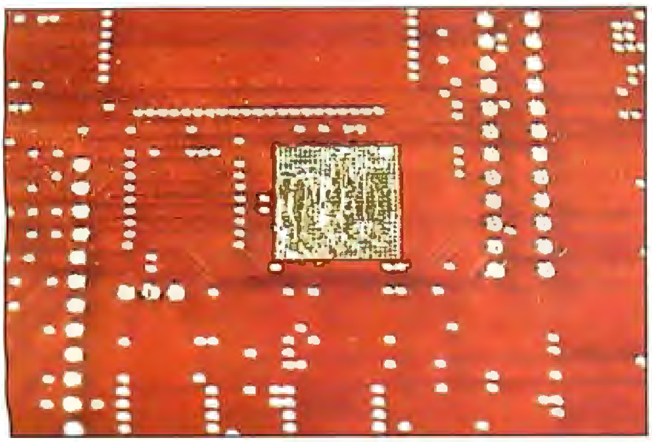

Photo 3: *The bottom of the motherboard. The square metallic grids match up with support posts on the outer case.*

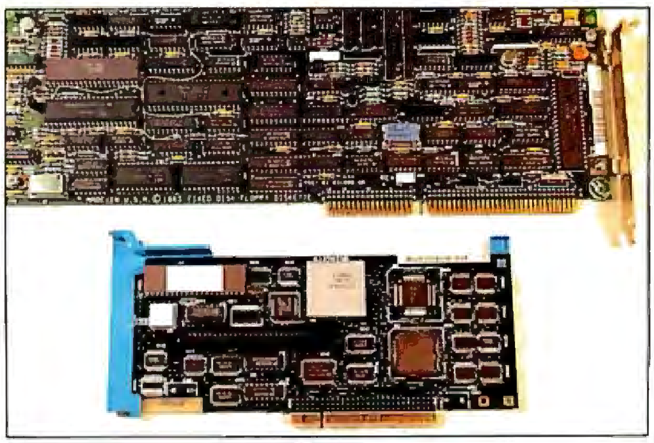

Photo 4: *The PC AT's hard and floppy disk controller (top) versus the Model 50's hard disk controller (bottom).*

Rear of the System Board

	B		A
Auxiliary Video Extension	ESync	V10	VSync
	Ground	V09	HSync
	P5	V08	Blank
	P4	V07	Ground
	P3	V06	P6
	Ground	V05	EDclk
	P2	V04	DClk
	P1	V03	Ground
	P0	V02	P7
	Ground	V01	EVideo
		KEY	
8-Bit Section	Audio Gnd	01	-CD Setup
	Audio	02	MADE24
	Ground	03	Ground
	14.3 MHz	04	A11
	Ground	05	A10
	A23	06	A09
	A22	07	+5V
	A21	08	A08
	Ground	09	A07
	A20	10	A06
	A19	11	+5V
	A18	12	A05
	Ground	13	A04
	A17	14	A03
	A16	15	+5V
	A15	16	A02
	Ground	17	A01
	A14	18	A00
	A13	19	+12V
	A12	20	-ADL
	Ground	21	-Preempt
	-IRQ 09	22	-Burst
	-IRQ 03	23	-12V
	-IRQ 04	24	ARB 00
	Ground	25	ARB 01
	-IRQ 05	26	ARB 02
	-IRQ 06	27	-12V
	-IRQ 07	28	ARB 03
	Ground	29	Arb/-Gnt
	Reserved	30	-TC
	Reserved	31	+5V
	-ChChk	32	-S0
	Ground	33	-S1
	-Cmd	34	M/-IO
	ChRdyRtn	35	+12V
	-CD Sfdbk	36	CD ChRdy
	Ground	37	D00
	D01	38	D02
	D03	39	+5V
	D04	40	D05
	Ground	41	D06
	ChReset	42	D07
	Reserved	43	Ground
	Reserved	44	-DS 16 Rtn
	Ground	45	-Refresh
		KEY	
		KEY	
16-Bit Extention	D08	48	+5V
	D09	49	D10
	Ground	50	D11
	D12	51	D13
	D14	52	+12V
	D15	53	Reserved
	Ground	54	-SBHE
	-IRQ 10	55	-CD DS 16
	-IRQ 11	56	+5V
	-IRQ 12	57	-IRQ 14
	Ground	58	-IRQ 15

Key

Abbreviation	Full Line Name
A0 to A23	Address bits 0 to 23
-ADL	-Address Decode Latch
ARB0 to ARB3	Arbitration Bus 0 to 3
Arb/-Gnt	Arbitrate/-Grant (used in arbitrating access to bus)
Audio	Audtio sum mode
Audio Gnd	Audio Ground
Blank	Used to blank the output of the video DAC
-Burst	-Burst (used to signal extended use of bus in burst mode)
-CD DS 16[1]	-Card Data Size 16 (indicates 16-bit data on bus)
-CD Sfdbk[1]	-Card Selected Feedback
CD ChRdy[1]	Channel Ready
-CD Setup[1]	-Card Setup
-ChChk	-Channel Check (indicates serious system error)
ChRdyRtn	Channel Ready Return
ChReset	Channel Reset
-CMD	-Command (denotes valid data on data bus)
D0 to D15	Data bits 0 to 15
DClk	Latches P7-P0 signals
-DS 16 Rtn	-Data Size 16 Return
EDclk	Gates DClk[2]
ESync	Gates Blank, VSync, and HSync[2]
EVideo	Gates P7-P0[2]
HSync	Horizontal sync
-IRQ 3 to 7, 9 to 12, 14, 15	-Interrupt Request lines (used to signal I/O slave's need for servicing)
M/-IO	Memory/-Input/Output (distinguishes memory from I/O cycle)
MADE 24	Memory Address Enable 24 (active if current address is in the first 16 megabytes of the address space)
P7-P0	Pixel address inputs to video DAC
-Preempt	-Preempt (used to request use of the bus)
-Refresh	-Refresh
-S0, -S1	Status bits 0 and 1 (define the type of bus cycle)
-SBHE	-System Byte High Enable
-TC	-Terminal Count
VSync	Vertical sync

1. These are separate, dedicated lines running to each slot.
2. So that a plug-in video board can take control of these signals.

Figure 1: *The pin-outs for the various sections of the Micro Channel.*

doesn't relinquish control within 7.8 microseconds (μs) of a -Preempt, the Micro Channel times out and causes an error.

The nonmaskable interrupt (NMI) is assigned an arbitration level higher than any programmable device on the Micro Channel. This ensures that a critical error will be recognized, no matter what else is going on. Unfortunately, RAM -Refresh is still handled on the Micro Channel and is assigned a priority even higher than the NMI. Thus, DMA transfers will "burp" every 15 μs or so when -Refresh occurs. The technical reference manual notes that about 7 percent of the Micro Channel's bandwidth is dedicated to -Refresh. I'd be happy to pay more for a RAM controller to get -Refresh off the Micro Channel in exchange for smooth DMA transfers. Maybe next time. . .in the PS/3.

Listing 1: *A sample Adapter Definition File (ADF).*

```
AdapterId 0EEFFh
AdapterName "IBM Dual Async Adapter"
NumBytes 1
NamedItem
          Prompt "Connector 1"
        choice "SERIAL_1" pos[0]=XXXX000Xb io 03f8h-03ffh int 4
        choice "SERIAL_2" pos[0]=XXXX001Xb io 02f8h-02ffh int 3
        choice "SERIAL_3" pos[0]=XXXX010Xb io 3220h-3227h int 3
        choice "SERIAL_4" pos[0]=XXXX011Xb io 3228h-322fh int 3
        choice "SERIAL_5" pos[0]=XXXX100Xb io 4220h-4227h int 3
        choice "SERIAL_6" pos[0]=XXXX101Xb io 4228h-422fh int 3
        choice "SERIAL_7" pos[0]=XXXX110Xb io 5220h-5227h int 3
        choice "SERIAL_8" pos[0]=XXXX111Xb io 5228h-522fh int 3
  Help
"This connector on the IBM Dual Async Adapter can be
assigned to use Serial 1 through Serial 8. Use the
F5=Previous and the F6=Next keys to change serial port
assignments if you are in the 'Change configuration' window.
Conflicting assignments are marked with an asterisk and
must be changed to use the adapter."

NamedItem
          Prompt "Connector 2"
        choice "SERIAL_1" pos[0]=1000XXXXb io 03f8h-03ffh int 4
        choice "SERIAL_2" pos[0]=1001XXXXb io 02f8h-02ffh int 3
        choice "SERIAL_3" pos[0]=1010XXXXb io 3220h-3227h int 3
        choice "SERIAL_4" pos[0]=1011XXXXb io 3228h-322fh int 3
        choice "SERIAL_5" pos[0]=1100XXXXb io 4220h-4227h int 3
        choice "SERIAL_6" pos[0]=1101XXXXb io 4228h-422fh int 3
        choice "SERIAL_7" pos[0]=1110XXXXb io 5220h-5227h int 3
        choice "SERIAL_8" pos[0]=1111XXXXb io 5228h-522fh int 3
  Help
"This connector on the IBM Dual Async Adapter can be
assigned to use Serial 1 through Serial 8. Use the
F5=Previous and the F6=Next keys to change serial port
assignments if you are in the 'Change configuration' window.
Conflicting assignments are marked with an asterisk and
must be changed to use the adapter."
```

POS and POST

The PS/2 includes a new feature called Programmable Option Select (POS), which allows you to set up all configuration information with software rather than with DIP switches or jumpers. In fact, the technical reference manual specifically prohibits DIP switches and jumpers on cards. The Power-On Self Test (POST) software initializes the cards when the power is turned on, so you're assured of the right setup every time. You can also display which cards are installed in which connectors, which ports they're configured to use, which interrupts are active, and so forth, right on the screen without removing the machine's cover. Even better, you can change the configuration from the keyboard without having to figure out which switch is which.

The line called -CD Setup (Card Setup) forces the card to a mode where it responds to I/O operations at addresses 100 to 107 hexadecimal, regardless of its normal addressing. There is a separate -CD Setup line for each Micro Channel connector, another for the video hardware, and another for the rest of the motherboard hardware. As you might expect, only one of the -CD Setup lines can be active at a time, because all the hardware responds to I/O at the same addresses during setup.

The POST code first determines what hardware is installed and then verifies that it matches the configuration information stored in CMOS RAM. If everything matches, the cards are initialized by writing configuration data into their registers. If you decide to change the cards, the POST code tells you to run the System Configuration program to create a new configuration file. You can't use the PS/2 until all the hardware is correctly initialized.

Both the POST code and the System Configuration program read a pair of identification (ID) bytes from each card. The hexadecimal representation of these bytes specifies an Adapter Definition File (ADF) on disk that defines all the possible setup variations for that card. For example, the ID bytes for the IBM Dual Async Adapter card are EE and FF hexadecimal, so the ADF filename is @EEFF.ADF. Listing 1 shows the contents of that file. Note that serial ports 2 through 8 share -IRQ3.

Because the system we received didn't have any additional cards installed, we couldn't fiddle around with the System Configuration program as much as I wanted to, but the principle is excellent. For the first time, it's possible to give online help to a user trying to resolve conflicts between various cards in the system, and that's a step in the right direction.

One possible snag: IBM is assigning unique IDs only for its own cards. The rest of us are on our own, so you can rest assured that two companies will introduce two different cards with the same ID. How this will be resolved is up in the air, but I'm sure one of the two will have to install a jumper block to select the card ID. That's the way it goes.

I'm quite sure that the automatic configuration works, because I used it after taking the system completely apart. The configuration data is stored in a battery-backed CMOS RAM on the motherboard. The battery is located on the subchassis just over the speaker. After about 15 minutes, the data in the CMOS RAM evaporates. Of course, I didn't think of that when the PS/2 didn't power up correctly. I could only imagine how annoyed BYTE was going to be when I returned a dead loaner.

Having nothing to lose, I booted up the Reference Disk. A utility automatically deciphered the error numbers into plain English: The CMOS date and time were invalid, and the battery was dead. It reminded me that this will happen whenever the battery is dead or freshly installed. I reset the date and time and then

continued

let the utility automatically identify the hardware. It reloaded the CMOS RAM and rebooted the PS/2. Elapsed time: under 5 minutes. Whew!

Opening Night Performance

It's difficult to decide what to test on a machine that's so new you don't even have cards that fit the sockets. I decided to run some timing exercises to measure how well the PS/2 could handle interrupts. I make no pretensions that these are comprehensive tests; the code is certainly not optimized.

The parallel printer ports on the PC AT and PS/2 can generate a hardware interrupt from a pulse on the Ack line. We replaced the standard interrupt handler with a specialized one for these tests. An oscilloscope connected to the Ack line and an output-port bit controlled by the interrupt handler allowed us to measure the time delays (see figure 2).

Because the test programs were written on the PC AT, I got some first-hand experience with the IBM PS/2 Data Migration Facility. The DMF is an adapter that connects a PC AT (or PC) printer cable to the PS/2's printer port. The COPY35 program (on a 5¼-inch disk) sends files from the PC AT's disk to RECV35 (on 3½-inch disk), which receives the file and stores it on the PS/2's disk. Sounds simple enough.

There was, of course, a slight complication. The PS/2's POST decided that when the parallel printer port had the DMF adapter installed, it wasn't a printer port, so it omitted the port address from the BIOS data area. Our test programs read the port address from that area, as all good programs should, rather than hardcoding the addresses as constants. After a little team discussion, we wrote a tiny Debug script to force the right address back into RAM. Mutter. Grumble.

Figure 3 shows the general outline of

continued

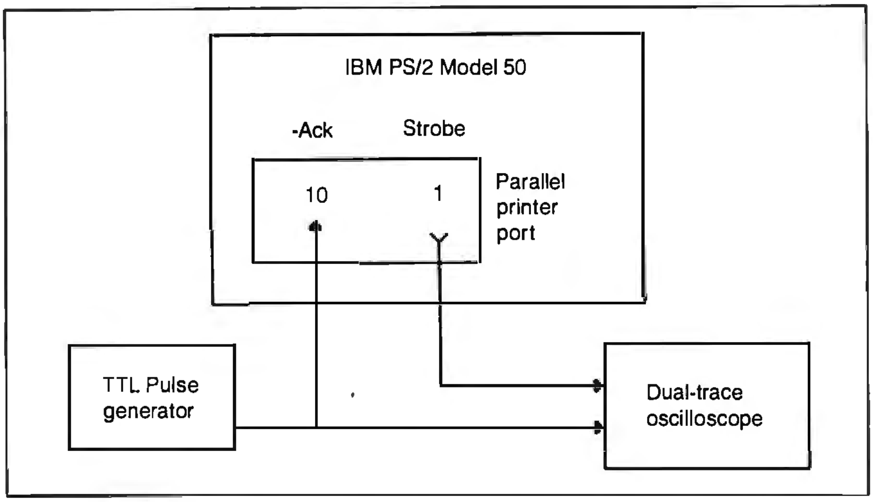

Figure 2: *Our interrupt test hardware. We replaced the standard interrupt handler for the PS/2's parallel printer port with a specialized one. We measured the interrupt time delays by connecting a dual-trace oscilloscope to both the Ack line and an output-port bit controlled by the interrupt handler.*

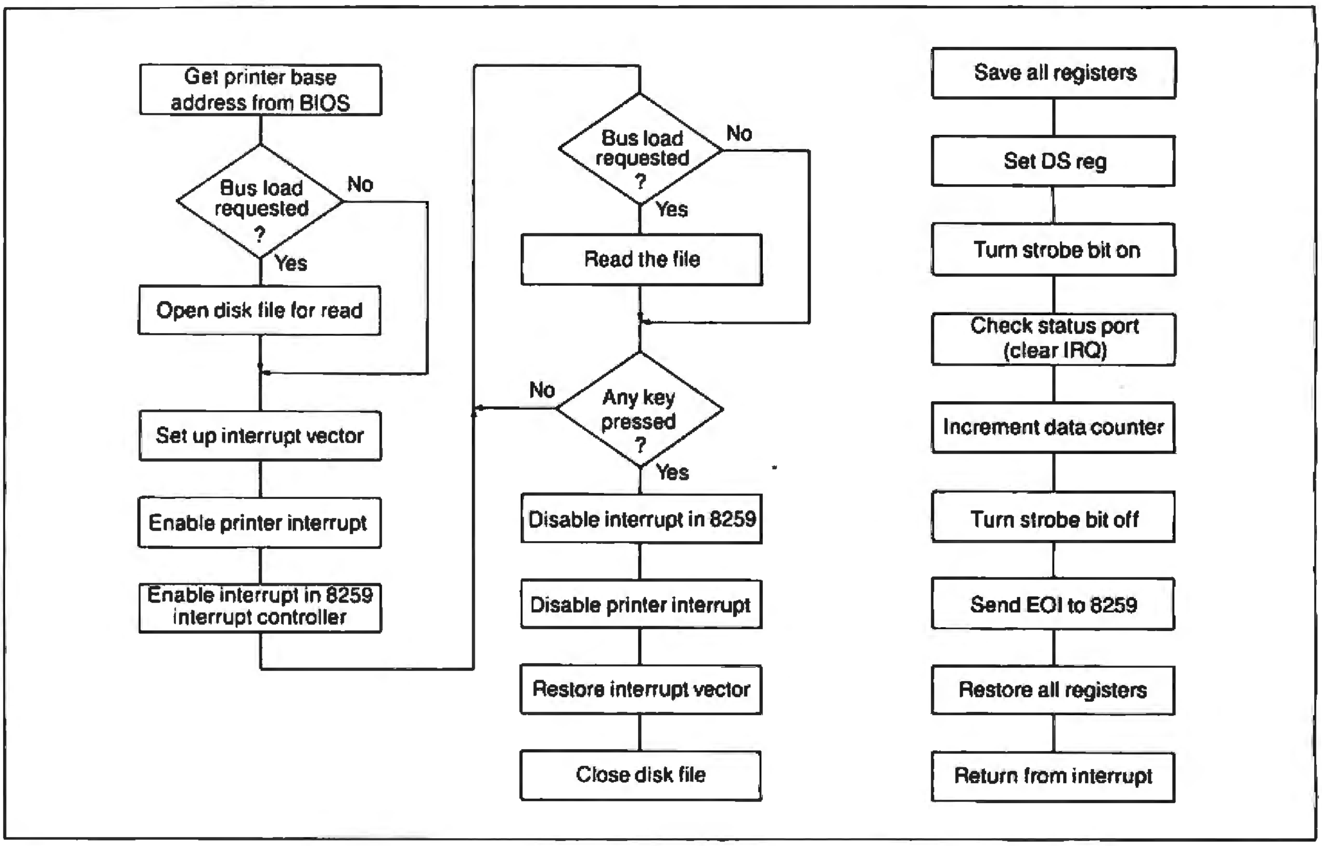

Figure 3: *The interrupt test program: 3a shows a general outline of the main program's operations; 3b contains the functions performed by the program's interrupt-handler section, detailed in listing 2.*

Listing 2: *The IRQTEST.ASM interrupt handler.*

```
;----------
; The Interrupt Handler!
; Gets control on interrupt from parallel port LPT1
; Increments counter and updates port data value
; This is deliberately not optimized...
.
                assume   cs:comseg,ds:comseg,es:nothing,ss:nothing

irq             proc     far
                sti                                 ; allow other interrupts
                pusha                               ; 80286 save all regs
                push     ds                         ; ... and seg reg
                mov      ax,cs                      ; set seg reg
                mov      ds,ax

;--- set processing flag
                mov      dx,prtctls
                punt
                in       al,dx
                or       al,mask stb                ; turn bit on
                punt
                out      dx,al                      ; tell the world

;--- check status port
;    required on PS/2 to clear interrupt flag
;    if interrupts were shared, we should check irq status bit
                mov      dx,prtstat
                in       al,dx

;--- tick counter so we can see things happen
                mov      dx,prtbase                 ; get printer data port
                punt
                in       al,dx                      ; get current port data
                inc      al                         ; tick the counter
                punt
                out      dx,al                      ; send new value out

;--- clear processing flag
                mov      dx,prtctls
                punt
                in       al,dx
                and      al,not mask stb            ; turn bit off
                punt
                out      dx,al

;--- reset hardware and return
                cli
                mov      al,eoi                     ; reset interrupt controller
                punt
                out      i8259,al
                pop      ds                         ; restore seg reg
                popa                                ; 80286 restore all regs
                iret
irq             endp
```

the test program, and listing 2 shows the interrupt-handler section. The program assumes that it's running on an 80286, but it will run unchanged on either a PC AT or a PS/2 system. We needed some interesting tricks to use the new level-sensitive interrupt hardware. For example, the interrupt handler reads the printer-status port. If several cards are sharing the hardware-interrupt line, there is a test to make sure that the printer port caused the interrupt. If you don't read the status port, the hardware won't reset the interrupt-pending bit, and the PS/2 *will* hang in a tight loop, responding to a stuck interrupt. It's easy to spot on the scope, but the technical reference manual makes no mention of that requirement.

Time Trials

First, we measured interrupt-response time (see figure 4) with a minimal system load. The PS/2's timings (see photo 5) registered a minimum of a 15-μs delay from the rising edge of the Ack line to the first interrupt-response output. The PC

AT weighed in at about 20 μs (see photo 6). The 10-MHz Model 50 runs about 25 percent faster than an 8-MHz AT—simply the ratio of the clock frequencies.

The PS/2's printer port produces much cleaner pulses than the PC AT's. Although the specifications say that both ports use the same pull-up resistor, it must be that the PS/2 has an active pull-up, the monochrome card on our test PC AT had some problems, or the difference is the result of the PS/2's better shielding and busing.

If the processors are busy with a non-interruptible task when the interrupt is presented, you get a variation in response times. For example, the hardware-timer interrupt occurs 18.2 times per second and can't be interrupted by the lower-priority printer interrupt. The DOS call I used to check for a key press might also disable interrupts occasionally.

The longest delay on the PS/2 was about 60 μs, compared to the PC AT's 80 μs. Again, these are roughly proportional to the clock ratio, so I wasn't surprised. Some of the interrupts are lengthened because a timer interrupt occurs while they are active. There was no easy way to measure the increased time, but it seemed to be roughly 10 to 20 μs.

I wanted to measure the effect of the new Micro Channel arbitration on the interrupt-response time, so we added a DOS call to read a disk file while the interrupts were active. Listing 3 shows the main loop. When the bus load is not zero, the DOS calls are assembled. Each read pulls in 10,000 bytes of data from the file. For the sake of simplicity, we used COMMAND.COM as the test file. The latency remains about 60 μs, but the longest delay grew to over 300 μs. You can stretch the interrupt to more than 200 μs with Micro Channel operations that have a higher priority.

What's going on is that the printer-port interrupt is now contending with the disk-controller data transfers. It appears that the controller is using a DMA transfer with a higher priority than the printer-port interrupt. The delays and stretched interrupts are due to that arbitration.

For comparison, if you run the same program on the PC AT, there is absolutely no interference from the disk. A quick check of the PC AT BIOS listing will tell you that the PC AT doesn't use DMA for the hard disk; it uses a program loop to transfer sectors from the controller card to RAM. And those transfer loops are interruptible by the printer port. Surprised?

Listing 3: *The IRQTEST.ASM main test loop.*

```
;--- Stall in this loop until a key is pressed
;    Interrupts are presumably blazing away...
;    Bus load is produced by repeated disk reads

            mov        dx,offset runmsg
            doscall    showstr
keywait     label      near
            IF         busload
            mov        bx,handle              ; get to start of file
            mov        al,0
            mov        cx,0
            mov        dx,0
            doscall    seek
            jc         oops
            mov        bx,handle
            mov        cx,readlen
            mov        dx,offset filebuff
            doscall    read
            jc         oops
            cmp        ax,cx                  ; full read?
            jne        oops
            ENDIF
            mov        dl,0FFH                ; no wait on keyboard test
            doscall    dircons                ; get char, if any ready
            jz         keywait                ; no char => Z flag set
            jmp        cleanup                ; exit to cleanup code
oops        label      near                   ; in case of disk errors
            mov        dx,offset errmsg3
            doscall    showstr
```

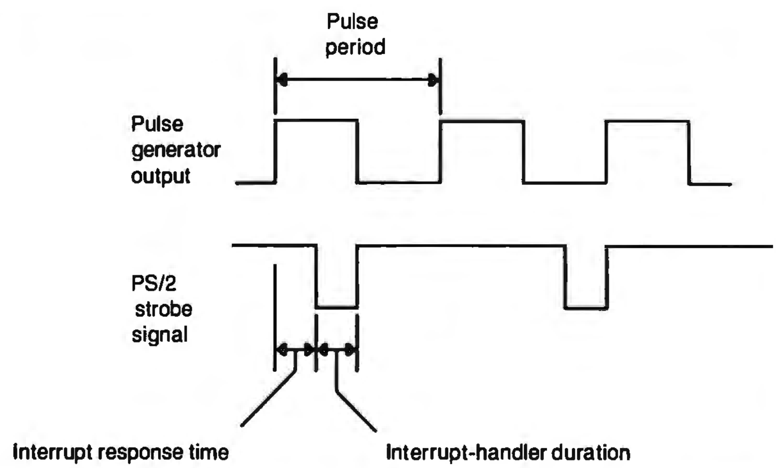

Figure 4: *The interrupt timings. The delay equates to the interrupt-response time, or the length of time between presenting the interrupt and the response of the interrupt handler.*

More Value Than Aggravation

IBM is preparing for a multitasking operating system (the long-awaited OS/2), so many of the decisions in the BIOS are made on that basis. Using DMA to transfer the data lets the new hardware arbitrate on a cycle-by-cycle basis between contending Micro Channel users. It's your job to match the hardware and BIOS functions to the task at hand. Make sure that you measure the system under real-life conditions to avoid surprises.

If all you're doing is running spreadsheets, there are cheaper ways to get 25 percent more speed than buying a PS/2 machine. But if you're building systems that get down to the bare metal, the Micro Channel will make your life a lot easier. One complication is that the BIOS listings aren't around to bail you out of tight spots. You have to depend on the published interfaces. Time will tell if all the critical details show up in the manuals.

Only IBM could introduce a new PC system with an incompatible bus, differ-

continued

Photo 5: *An oscilloscope shot of a simple interrupt response on the Model 50.*

Photo 6: *An oscilloscope shot of a simple interrupt response on the PC AT.*

ent video adapters and displays, *yet another* keyboard interface, and a pair of incompatible floppy disk formats and still call it PC-compatible. Anyone else trying to pull this off would suffer The Death of 10,000 Paper Cuts in the published reviews. But the IBM people define what they mean by PC-compatible, so they can get away with it as long as the product supplies more value than aggravation. The PCjr, Portable PC, and PC Convertible didn't, but the PS/2 does. IBM doesn't have to apologize for this one.

I'm most impressed with the level of care and attention that's gone into defining and specifying the requirements for new Micro Channel cards and programs. The Micro Channel allows simple, automated device setup, has the potential to support intelligent I/O subsystems, and has room for growth. The PS/2 looks good, and I'm looking forward to some interesting projects with it. ■

Special thanks to Ed Nisley for his collaboration on this article.

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Head to Head

The IBM PS/2 Model 80 and the Apple Macintosh II

Last month, we began to examine the newest generation of personal computers built around the Intel 80386 and the Motorola 68020 CPUs. In "High-Tech Horsepower" (July BYTE), we compared the relative performances of the Compaq Deskpro 386 and the Macintosh SE boosted by General Computer's HyperCharger board.

This month, we look at the IBM Personal System/2 Model 80 and the Macintosh II. We benchmarked the Mac II at BYTE on a machine loaned to us by Apple for review. (Further information on the Mac II is available in our product preview, "The Apple Macintosh II," April BYTE.) To get our results on IBM's machine, we traveled to Boca Raton, Florida, soon after the PS/2 line was announced. We tested a Model 80 that IBM makes available to software developers who want to run software-compatibility tests on announced machines that are not yet shipping. But first, let's look at the technology used by IBM in building this 80386-based machine.

IBM's New Technology

The Model 80 comes in a floor-standing cabinet similar to that of the Model 60 (see the text box accompanying our review, "The IBM PS/2 Model 50," July). The bottom of the Model 80's motherboard (planar board in "Bluespeak") contains the Intel 80386 and optional 80387 plus five 16-bit and three 32-bit connectors for the Micro Channel bus. The hard disk (fixed disk in Bluespeak) controller board occupies one of the 16-bit slots; another slot features a VGA (Video Graphics Array) extension.

The Model 80's 32-bit version of the Micro Channel is designed for memory expansion and for building multiprocessor machines on a Model 80 platform. The 32-bit Micro Channel offers increased speed on memory-to-processor data transfers—over and above the speed increases expected from using a 32-bit data path—due to the *matched memory cycle*. This bus-transfer protocol uses three additional control bits to tell the 32-bit Micro Channel to make a complete data transfer in 187.5 nanoseconds, a one-wait-state transfer on a 16-MHz 80386. This contrasts with a 250-ns data-transfer period, called the *basic transfer cycle*, which is the default on the 32-bit Micro Channel. (By comparison, the transfer-cycle time on the 16-bit Micro Channel used on the PS/2 Models 50 and 60 is 312.5 ns.)

Lining up data on double-word boundaries increases performance on the 32-bit Micro Channel. However, peripheral I/O is limited by design to a 16-bit data path and thus its performance remains the same regardless of Micro Channel width. The Model 80 uses relative block addressing for disk I/O. Since MS-DOS uses physical block addressing, the device drivers convert physical addresses to relative addresses for the ESDI (enhanced small device interface) hard disk controller.

The Model 80 comes in three versions: the 16-MHz Models 80-041 and 80-071, both of which use 512K-bit by 1-bit memory chips, and the 20-MHz Model 80-111, which uses 1-megabit by 1-bit chips; both sizes have an 80-ns access time. The difference between their capacities allows room for 2 megabytes of memory daughterboards on the 80-041 and 80-071 motherboards and 4 megabytes on the 80-111. Memory expansion boards can meet any additional memory requirements. The difference between the 80-041 and the 80-071 lies in their hard disk capacity: The 80-041 includes a 44-megabyte hard disk, while the 80-071's has 70 megabytes. The hard disk on the 80-111 has a capacity of 115 megabytes.

There is a high level of BIOS compatibility with the IBM PC with two distinct exceptions. First, programs dependent on a set execution time will not run due to the increased processor speed. Second, programs that address the top 1K of the 640K bytes of memory normally available to MS-DOS will not run properly. This 1024 bytes is used by a larger BIOS, which contains extensions to aid in the creation of a multitasking environment. However, the vast majority of software written for the PC should execute normally.

Coming Before the Bench

We ran the PS/2 Model 80 benchmarks on an 80-071 machine with two 70-megabyte drives, a 1-megabyte cache, 1 megabyte of RAM, and a 16-MHz Intel 80387. The protected-mode tests were run with the Phar Lap RUN386 program, a utility that puts the 80386 into protected mode. The Model 80 consistently hung at the completion of this program's run, possibly due to a problem with interrupt masking. The benchmark results are shown in table 1 opposite those of the Compaq Deskpro 386 and the IBM PC AT.

The Deskpro 386 executes the Fibonacci and Sieve benchmarks faster than the Model 80—most likely due to the Deskpro's use of static RAM. While both machines use one wait state for processor-to-memory accesses, the Model 80

continued

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Table 1: *Benchmark results for the Intel 80x86 machines.*

	IBM PS/2 Model 80	Compaq Deskpro 386	IBM PC AT with FPU
CPU	16-MHz 80386	16-MHz 80386	8-MHz 80286
FPU	16-MHz 80387	8-MHz 80287	8-MHz 80287
Fibonacci	57.40	53.10	120.96
Float	0.48	4.41	9.70
Sieve	6.46	5.98	25.29
Sort	9.47	9.67	45.73
Savage	19.20	35.10	38.28
Dhrystones per second	3125.00	3707.00	1748.90

Table 2: *Benchmark results for the Motorola 680x0 machines.*

	Mac II	Mac SE with HyperCharger	Mac SE
CPU	15.67-MHz 68020	15.67-MHz 68020	7.83-MHz 68000
FPU	15.67-MHz 68881	7.83-MHz 68881	7.83-MHz 68881
Fibonacci	83.70	71.60	264.00
Float	2.70	4.16	229.98
Sieve	16.70	14.94	64.70
Sort	22.40	19.82	111.30
Savage	5.40	8.78	1884.30
Dhrystones per second	2083.00	2114.00	574.00

must refresh its RAM every 125 ns while the static RAM of the Deskpro 386 requires no memory refresh.

On the other hand, the 16-MHz 80387 in the Model 80 dramatically improves its execution of the Float and Savage floating-point benchmarks over the Deskpro 386's 80287 running at 8 MHz—very understandable. Megahertz alone can explain part of the difference.

More difficult to explain, however, is the significant difference between the two Dhrystone benchmarks. Both computers use the same Intel 80386 CPU, and both run it at 16 MHz, but the Compaq Deskpro 386 appears to get more out of it—18 percent more.

The Mac II on which we executed our benchmarks had a 40-megabyte hard disk and 1 megabyte of RAM. We did not recompile our tests on the Mac II. Instead, we used the executable code produced by the Mac SE; it ran without a hitch. The benchmark results are shown in table 2 opposite those of the Mac SE with HyperCharger and the Mac SE.

The Mac II is actually slower on the calculation-intensive, array-manipulation benchmarks (Fibonacci, Sieve, and Sort) than the Mac SE with HyperCharger. On the other hand, the Mac II's 15.67-MHz 68881 provides a great improvement over the Mac SE with HyperCharger's 7.83-MHz 68881 in floating-point operations (the Float and Savage benchmarks). The reason, again, is largely megahertz. The difference between the 68020 processors in the Dhrystone benchmark is negligible.

And the Mac II versus the Model 80? On these tests, the Model 80 outperformed the Mac II with one exception: the Savage benchmark, which tests floating-point transcendentals. This benchmark is particularly useful for testing numeric-coprocessor boards. While both the 80387 and the 68881 have on-board transcendentals, either the functions tested by the Savage benchmark work better on the 68881, or the benchmark is coded more efficiently for the Mac II.

In effect, you can make the same inference for the other benchmarks as well: Either the functions we tested work better on the Model 80, or the benchmarks are coded more efficiently for it. Please understand that these benchmarks have not been intentionally optimized for individual CPUs or FPUs. You can make comparisons, but they cannot be as clear cut as you might like. All we can say, with honesty, is that *on these tests*, the Personal System/2 Model 80 outdistanced the Mac II. ■

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Steve Ciarcia

Part 2: Colorization

Using the ImageWise Video Digitizer

Take digitized black-and-white images and convert them to color

Presuming that you aren't tired of ImageWise and the subject of video processing yet, I thought I'd stick in one more video project before I go on to other matters. Actually, I have probably picked a subject that you might know something about. The coloring of black-and-white motion pictures has been the subject of many heated debates in the entertainment industry. Movies like *The Maltese Falcon*, *Yankee Doodle Dandy*, and *Captain Blood* have been converted from their original black-and-white state to color using sophisticated computer-controlled hardware. Using computers to color these films has caused a great deal of discussion about the economic, aesthetic, and even the moral implications of modifying what many call works of art.

While colorization of movies is controversial, the technical aspects of the process are just another form of video processing and a continuation of the materials we discussed last month. With the help of your personal computer and the ImageWise video digitizer, you can experiment with colorization and form your own opinion.

This month, I will describe the software and techniques you need to add color to the black-and-white images captured with ImageWise. But before we start, let's look at the techniques Hollywood uses to color black-and-white motion pictures.

How Hollywood Does It

Converting a black-and-white film to color is a complex job that requires the talents of many people—one firm has almost 200 people working three shifts a day, seven days a week. And even with that many people involved, it takes about four months to color a full-length movie. Besides being labor-intensive, coloring a film is also expensive, with the current cost being about $3000 per *minute* of finished product. A two-hour movie costs almost $400,000 to color. While this is not cheap, it is a bargain compared to the cost of making a new film.

First, they make a print from the original film's black-and-white negative and then transfer it to videotape. This videotape is the copy they use for all work; the original film is not modified. Incidentally, the coloring process may help preserve the original picture, since old movies used nitrate film that deteriorates with age. The new print made for transfer to videotape is made using modern film stock that will be around long after the original has disintegrated.

After they transfer the film to videotape, the difficult task of determining what colors were used in the original film begins. They talk to members of the movie's cast and crew and search libraries and studio archives for color photos and set descriptions taken during the original production. The movie is also viewed to see if known objects appear in it: famous paintings, landmarks, and other recognizable objects. If the true color of an object cannot be determined, an art director will select suitable colors.

At the same time they are determining the proper colors for the film, a shot-by-shot breakdown of the entire movie is done, with a code number assigned to each scene. The significant characters and elements of these scenes are noted, and the lists are given to the coloring staff, along with the colors that are to be used. It is important that the continuity of these lists be accurate, since many people will be working on the film. A mistake can result in one group painting a car black and another group painting the same car (in a different scene) red. If these scenes are next to each other in the final film, the audience will wonder where the red car came from.

After they have determined all the colors and generated the continuity lists, it is time to begin adding color to the movie. A colorist will watch the film scene by scene in black and white and electronically add color to the picture using six colors: black, red, blue, pink, yellow, and white. These colors do not represent the actual colors that will be used but are used as indicators of light levels. Black and red represent the darkest levels of the picture, white and yellow the lightest.

The colorist breaks the picture down into individual areas or layers. An example is a shot of a hand on a desk. If the hand will be moving around the top of the desk, the colorist draws a mask around the hand to isolate it from the desk. The desk is then colored, using any colors from the entire spectrum of an electronic palette. Since the colorist colors the entire desk, even areas "beneath" the hand, when the hand moves, the portion of the desk that was under the hand will already be colored. Next, the colorist applies fleshtones to the hand. As the hand moves from frame to frame of the film, a computer will remember what colors were used and will follow the hand with fleshtones as it moves.

The colorization process uses a combination of layering and assigning colors to

continued

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I discovered that the coloring companies are using IBM PC ATs and Apple Macintoshes.

gray levels. Coloring done only by assigning colors to gray levels in each frame does not achieve the quality you have come to recognize as a professionally colorized film, but it does offer a starting point. (Since layering is extremely software-intensive and beyond our ability to duplicate here, our experiment with colorizing images will use only gray levels. The limitations of this coloring technique will be obvious, but the process is still instructive.)

After all the layers for a scene are colored and the first and last frames of a shot are completed, the colorist will select key frames that have large changes or new objects in them. The next step is to reposition the old masks and add masks for new objects as required. This is necessary when an object that was on the top layer (the hand) moves behind a new object (like a lamp). The colorist will also make any changes to the previously selected colors to allow for shadows and lighting changes. Finally, after all colors are selected and the masks are determined, a computer automatically colors all frames in the scene with the selected colors.

The colorist repeats this process for every scene in the film. The finished color scenes are then edited back together in the proper sequence. The movie is then reviewed for proper color balance and continuity. If everything checks out, the company returns the finished product to the owner for distribution.

When I started researching this article, I thought that the coloring process was probably being done with a bunch of Cray supercomputers. But after some research, I discovered that the coloring companies are using IBM PC ATs and Apple Macintoshes running custom software and connected to custom video hardware. I thought, "If they can do it with micros, it can't be too difficult, right?" Well, the key components of the coloring system are the custom software and hardware. And since at least one company has $20 million invested in its custom coloring hardware, trying to duplicate its system might be a little beyond the Circuit Cellar budget for this month.

However, even though it isn't practical for us to duplicate that company's equipment, we have built and tested some of the key ingredients in the past three months. I thought we'd apply a little journalistic license and try to use the equipment we already own. We'll just have to interpret the results in the proper frame of mind.

Setting Up

My colorization system consisted of an IBM PC with one serial port, a Genoa Systems EGA video board, an NEC MultiSync monitor, and the ImageWise digitizer/transmitter, with a camera providing a picture source (it could be a VCR, TV signal, or any such thing). The Genoa Systems EGA is a half-size board that supports IBM and Hercules monochrome, IBM Color Graphics Adapter (CGA), and IBM Enhanced Graphics Adapter (EGA) video modes.

As you'll see, we face some obvious limitations using EGA. You might wonder why I did not use PGA, VGA, or—at the very least—my own GT180 (all of which would have resulted in a more "colorful" picture). My purpose here was not to create pretty pictures that prove I understand colorization and can afford the hardware. Rather, I am trying to find the greatest audience of experimenters who might be able to recreate these experiments (this is always the purpose of the Circuit Cellar). I chose the IBM PC with an EGA display as a reasonable compromise between installed base and minimum graphics capability. Of course, if you have an Amiga or any better IBM graphics board than an EGA, you can extend the basic concept for better results.

The ImageWise digitizer/transmitter generates a 256- by 256-pixel image with 6-bit, 64-level gray scale for each pixel. Ideally, we would like to use all 64 levels in our display, but the EGA board lets you choose only 16 colors from a palette of 64. To display a picture, we have to remap the 64 gray-level values from the digitizer/transmitter into 16 values from the EGA's color palette. Fortunately, since the images are 256 pixels wide, we can conveniently use a screen resolution of 320 by 200 (we will just ignore the bottom 56 lines of the image).

The process is relatively straight-forward. You aim a camera at a black-and-white photograph or illustration. Then, using the PC-DOS "digitize and store" utility provided with the ImageWise digitizer/transmitter, you digitize the image and store it to disk. Finally, using the "coloring" software provided for this project, you select and assign color values to the black-and-white digitized images.

This coloring program is much too big to list here, but it is available for downloading from the Circuit Cellar BBS at (203) 871-1988, provided it is for your own personal and noncommercial use. Alternatively, you can send me a formatted PC disk with return postage, and I'll load it with the pertinent files. The coloring program will run on any PC with at least 256K bytes of RAM and an EGA-compatible graphics display.

The coloring program lets you assign each of 64 gray levels to one of the 16 EGA palette positions. You choose these 16 palette colors from the 64 available EGA colors. Unfortunately, it is not simply a case of substituting one of these palette colors for all instances of a particular gray level. The manipulation of the gray levels and palette colors is what colorization is all about.

As I mentioned earlier, ImageWise digitizes images into 64 levels of gray. These levels are determined by the amount of light reflected by the objects we are processing. Because we are digitizing light levels and not colors, some parts of the digitized images will have the same gray level even though they may not be the same color in the original. This problem, combined with the minimal color capabilities of the EGA, limits the results we can achieve. But these limitations are not as severe as they may first appear, and you can minimize their effects by clever manipulation of the image data.

Before you begin, you will need a subject. While you can use just about anything, some subjects will give much better results than others. Try to avoid subjects with real people in them. The EGA color palette doesn't have any colors that are acceptable as fleshtones. Also avoid subjects that are dominated by a single color. The best subjects are those with lots of colors or gray levels.

Animated cartoons are good subjects since they have a wide range of colors and have distinct borders between different color zones. I chose a scene from Walt Disney's *Snow White and the Seven Dwarfs* as the subject for my examples. Disney Studios was happy to grant permission to use this film as the subject since this is its fiftieth anniversary. I neglected to say that Snow White might be "Snow Green" when I was done.

Photo 1a shows Snow White and Dopey after being digitized and displayed in 64-level gray scale using the ImageWise system. The picture shown here, as displayed on an ImageWise display/receiver board, provided the digitized data for the EGA colorized images that were eventually generated. (Generally speaking, an IBM PC cannot display a 64-level gray-scale image without advanced graphics boards or an ImageWise display/receiver board. However, a technique called *dot-dithering*, which creates a pseudo gray scale [e.g., like pictures in a newspaper], can be used to create a reasonable image on an EGA display. Photo 1b shows the same Snow White image in pseudo gray scale on an EGA.)

Before we begin adding color to this image, we need to decide on a method of mapping the 64 levels into the 16 colors supported by the EGA. One method of mapping the ImageWise gray levels to the EGA color palette is to ignore the 2 least significant bits of each gray-level value. You can do this by dividing each pixel data byte received from the ImageWise transmitter by four and using the integer result as the palette position. As a result, the lowest four gray levels will be mapped to palette position 0, the next four gray levels will be mapped to palette position 1, and so forth, until all 64 levels have been assigned to EGA palette positions 0 through 15. Photo 2 shows the results obtained using this method. Compare this to photo 1.

It is obvious that the colors in photo 2 are not correct. So far, we have only mapped the gray levels to palette positions with little concern for which parts of the picture are affected. The result can be red faces and blue hair. Instead, we need to select which color will be assigned to each palette position while keeping in mind which areas are painted with which colors. A somewhat more careful selection of colors (plus some fixed areas of gray, as I'll soon explain) can take the same data of photo 2 and present it with a distinct improvement, as shown in photo 3.

While the results are better, we can still make improvements. The new image has lots of gray and black pixels because the lowest 12 gray-level values received from the ImageWise transmitter are found in large numbers throughout the entire image. When we divided the gray-scale data by four, these 12 levels now occupy only three palette positions. The effect is to make large portions of the image that were distinctly different now appear equal in color.

For example, let's assume that the bottom of Snow White's dress when digitized has a gray level of 3 and the area in the upper left corner of the screen has a gray level of 1. Since our mapping scheme will assign both levels to palette position 0, the two different levels become the same color. When we try to make Snow White's dress yellow, we will also be making the upper left corner of the screen yellow. If we try to change the corner of the screen to some other color,

continued

Photo 1a: *Snow White and Dopey as digitized by ImageWise.*

Photo 1b: *The same image as displayed on an EGA 16-level gray scale.*

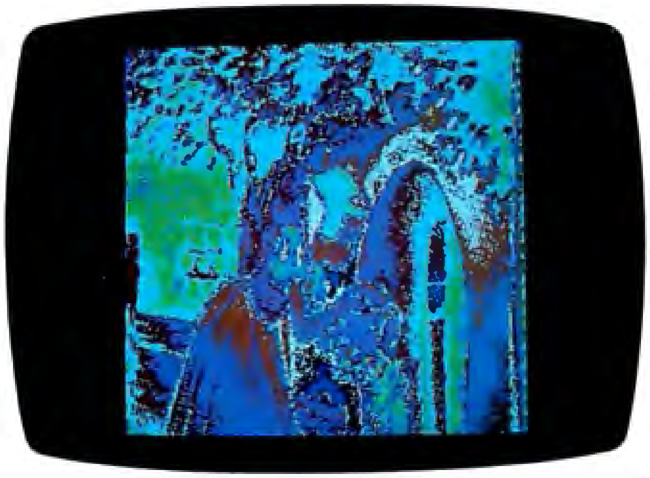

Photo 2: *A straightforward mapping of gray scale to EGA color-palette values. Each pixel in photo 1a is divided by four, and the integer result picks that pixel's color-palette value.*

Photo 3: *Mapping gray scale to color-palette values, as in photo 2. This time, however, we select colors with more care.*

the dress will change color, too.

To correct this sort of color Ping-Pong, we assign palette position 0 to actually be the color gray or black. This improves the way the image looks and is the easiest way to overcome the effect. Since we blindly combined every four gray levels into each palette position, the only way to get a reasonable-looking picture, such as photo 3, is to use lots of gray and black.

While this often results in an acceptable final image, we need a more precise way of mapping the gray levels to the EGA palette. Instead of blindly mapping every group of four gray levels to each palette position, we can achieve better results if each gray level from the original image can be mapped to any of the 16 palette positions. This also serves to avoid the color Ping-Pong problem.

The easiest way to implement this mapping method is to start by displaying information for 16 gray levels at a time. We can do this by mapping gray levels 0 through 15 to palette positions 0 through 15. We assign any gray level greater than 15 to palette position 0. By making the color of palette position 0 black, this hides all the gray levels greater than 15.

The result of this interim mapping scheme is shown in photo 4. Notice that the pixels that make up Snow White and Dopey are not shown. They have disappeared because they are composed of gray levels higher than 15, which we have assigned to palette position 0 (black). Thus, an added side effect of this mapping technique is the ability to separate the image into layers of light levels.

Once we have the first 16 raw gray levels to work with, we start the task of assigning them to palette positions. The coloring software lets us assign any of the EGA's 64 colors to each of the 16 palette positions very rapidly. A quick selection of available colors gives us photo 5. (The colors I selected are not necessarily the ones used in *Snow White and the Seven Dwarfs* because the EGA palette has a limited range of colors. My objective is more the procedure rather than the actual color quality of the results.)

At this point in the process, we don't actually use 16 different colors but rather assign the 16 original gray levels individually to some limited number of colors. If you use all 16 colors for these first 16 levels, these will be the only 16 colors you can use when selecting palette positions later for the higher gray-level values. Try to use just four or five different colors that are spread throughout the palette.

Photo 4: *Masking those gray levels mapped to palette positions greater than 15 simplifies the colorization process by letting you concentrate on 16 colors at a time, in this case, those pixels assigned to palette positions less than 16.*

Photo 5: *Using the masked image from photo 4, you can rapidly assign colors to the displayed pixels.*

Photo 6: *A reverse mask to photo 4. Now you can colorize pixels mapped to palette positions greater than 15.*

Photo 7: *Final result—the wonderful world of color.*

In photo 5, I used black, light green, dark green, light gray, dark gray, and brown (they become palette positions 0 through 5). The dark green color may be assigned to pixel gray-scale values of 4, 8, 13, and 14 as a typical example. Similarly, pixels with original gray-scale values of 0, 2, 3, and 15 might appear best if painted black. As you assign colors to a gray-scale value, you can see which pixels are affected and make a choice. Dark green leaves might look better against a blue sky than light green ones.

After we have selected the colors for the first 16 gray levels, we will repeat the process for the next 16 levels. We do this the same way except that this time we use gray-level values between 16 and 31. We will assign gray levels 0 through 15 and any levels greater than 31 to palette position 0 (black). As a result, gray levels 0 through 15 and those greater than 31 will not be visible.

Photo 6 shows levels 16 through 31 after we have selected colors. The new colors selected are purple, yellow, white, and pink. The software will combine these colors with the six we picked earlier, so the palette now has 10 colors assigned and 6 available for the remaining 32 gray levels. I repeated the color-selection process for levels 32 through 47 and levels 48 through 63, adding only a single new color, red.

As I mentioned earlier, grouping the gray-level data gave us a layered image even though that was not our intention. Snow White and Dopey are brighter than their surroundings and were digitized with higher gray-scale values. If these two fantasy characters were to be used independently or were more significant to you than the background colors, you could assign the majority of palette positions to their specific set of gray levels rather than the ascending order I described. Alternatively, we could make the background entirely black, dark gray, dark green, and brown to highlight Snow White. The effects that you can produce through the process of colorization are limitless (this is part of the controversy that is currently surrounding movie colorization).

After all 64 levels have been assigned a palette position, the coloring software will redraw the image, using the mapping and palette colors selected. The image you see in photo 7 shows the final results of our work after some minor reselection of colors.

Satisfactory Results

While the EGA's color capabilities are a limitation, careful manipulation of gray levels and color values can give us satisfactory results. One important fact to remember is that at no time have I rearranged, reprocessed, or otherwise manipulated the digitized pixel data in any way. We have achieved all of the results that you see here purely by assigning colors to specific gray-scale values from the original data.

One significant improvement to the coloring software would be the ability to load and save the final images in a format compatible with some of the PC drawing programs. You could use coloring software to map the gray levels and then the drawing program to fine-tune the images and borders between colors.

Some software of this type is already available. I have PC utility programs that convert ImageWise picture files to be compatible with PC paint programs such as PC Paintbrush, EGAPaint, and PC Paint Plus. Other utilities let you print a picture on a dot-matrix printer or a laser printer. (Contact CCI for details.)

For the past four months, I've tried to present the ImageWise system and software as the basis of a truly cost-effective image processing system. The response has been more than I could have hoped for, and ImageWise will join the Circuit Cellar all-time hit parade. Of course, that's until you see some of the other projects I've got up my sleeve.

Next Month

I'll show you the Circuit Cellar IBM PC AT–compatible computer, which consumes only 25 percent of the power of an AT, is 100 percent compatible, and is only the size of a PC expansion board. ■

Special thanks to Dave Lundberg for his software expertise and help on this project.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984.

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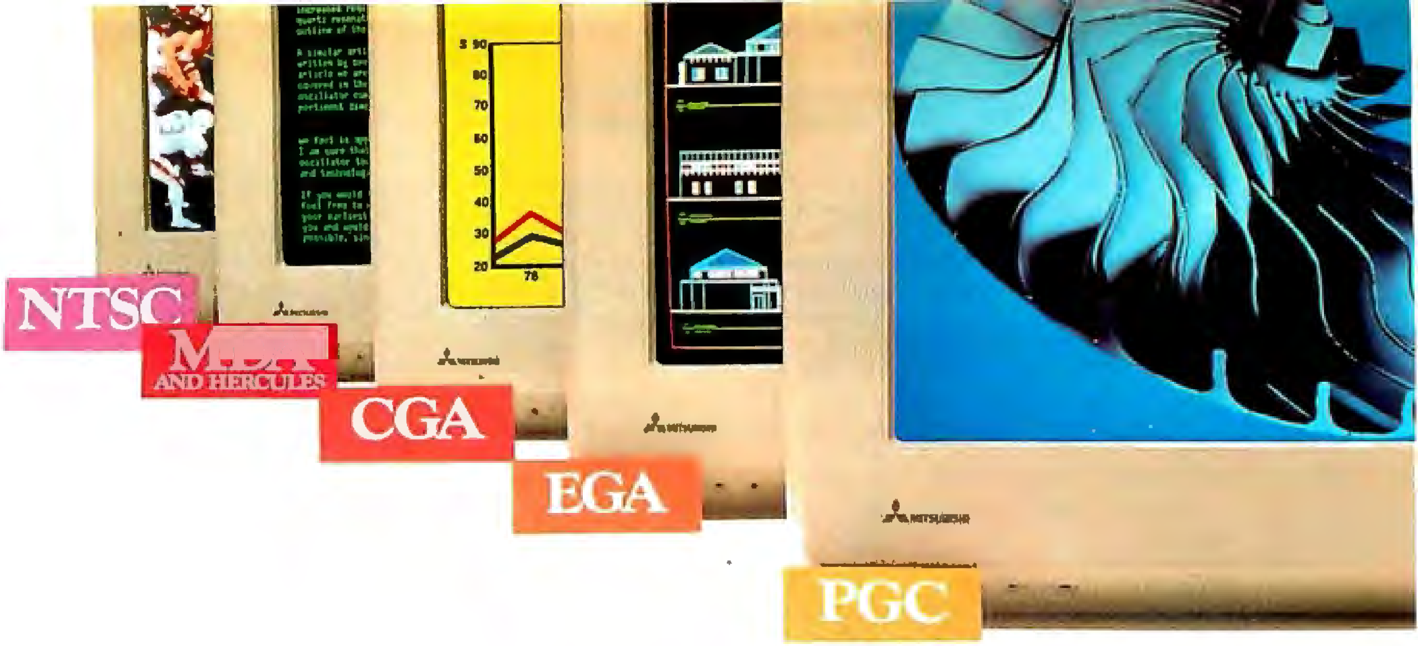

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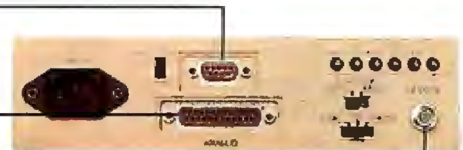

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William A. McWorter Jr. and Jane Morrill Tazelaar

Creating Fractals

Seeing a completed drawing of a dragon can't compare to the thrill of watching it being drawn

Fractals are a hot topic in science and mathematics these days. Their intricate organic shapes model nature's complex forms and processes.

The French mathematician Benoit B. Mandelbrot has spent most of his professional life studying those complex acts in nature that only chance can hope to simulate, such as transmission-line noise and linguistics. But something existed in natural events that unconstrained chance could not mimic. Mandelbrot tried to model nature with fractals, a term that comes from the Latin adjective fractus, meaning irregular or fragmented.

Bridging Order and Chaos

Chance was perfect for simulating a coin toss, but it is far too irregular to model the fluctuations of the stock market. To mimic many natural events, you can blend in fractals to bridge the chasm between order and chaos.

Mandelbrot's book, *The Fractal Geometry of Nature*, led to a discussion of what we will call regular fractals: those fractals that arise from an infinitely repeated construction process. Strangely, few regular fractals have appeared in print outside Mandelbrot's book, which contains many attractive examples. Most published fractals are the so-called *domains of attraction* (see "Fractals" by Peter Sørensen, September 1984 BYTE). Finding good examples of these domains of attraction is an arduous, hit-or-miss affair, while regular fractals are relatively easy to understand and draw.

Fractals are geometric objects, like points, lines, planes, and cubes. However, unlike more familiar shapes, fractals have a complexity that is impossible to measure by conventional methods. In

continued

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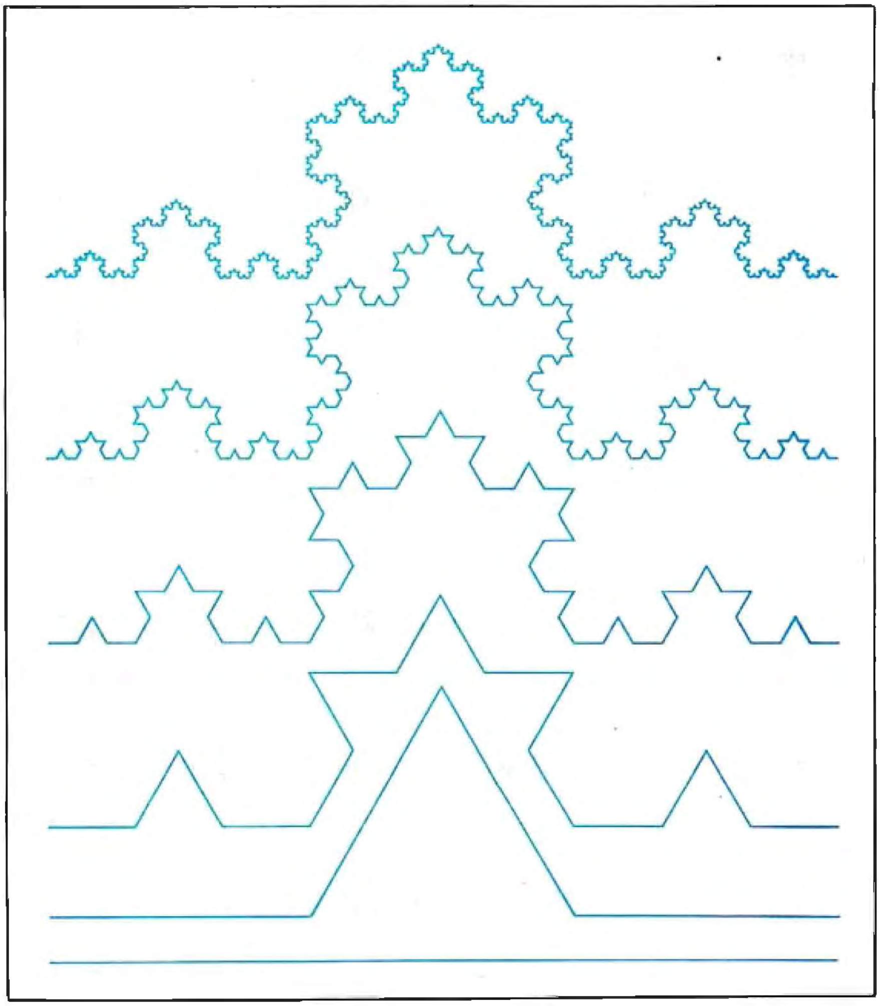

Figure 1: *The first few stages in the development of Koch's snowflake (see table 1, Koch's Snowflake).*

fact, you cannot even draw a fractal; you can only approximate it.

Consider, for example, Koch's snowflake curve, a regular fractal that looks more like a frayed rope than a curve. Figure 1 shows the first few stages of the repetitive generation process. The stage shown at the top of the figure suggests the ultimate look of Koch's snowflake curve.

Figure 2 shows five stages in the construction of Sierpinski's carpet. The early stages of this curve give the impression that it will eventually fill some area. But the area of all the holes is equal to the floor space of the smallest room that would contain the carpet, and therefore it covers no area at all! Yet, visually, it appears to be more dense than Koch's snowflake, which similarly appears to be thicker than a curve.

Standard mathematical analysis says that both curves are no more dense than a straight line, which covers no area. However, a maverick notion of dimension developed by Felix Hausdorff can differentiate between these curves. An ordinary curve has a Hausdorff dimension equal to its conventional dimension; that is, 1. The Hausdorff dimension of Koch's snowflake is approximately 1.2618, while that of Sierpinski's carpet is about 1.8928. Whereas conventional dimension can only determine whether an object does or does not fill a space, the Hausdorff dimension can measure what fraction of space an object covers (something like measuring the density of a cloud cover). Fractals live in a nether world between conventionally dimensioned spaces. Koch's snowflake and Sierpinski's carpet live in a world *between* their one-dimensional parts and their two-dimensional home. Hence, Mandelbrot defines a fractal as a geometric object with Hausdorff dimension greater than its conventional dimension.

Taking Up Space

Complicated curves can have considerable substance, filling whole areas or volumes. Hilbert's curve is the most famous of these (see figure 3). It fills a square and so is called a *space-filling* curve. It is not a fractal by Mandelbrot's definition because its Hausdorff dimension is 2, the same as its conventional dimension. (Two-dimensional fractals exist, but they are so crinkly or fragmented that they must live in three-dimensional space or higher.) Even so, Mandelbrot found that space-filling curves join with fractals in modeling nature. Some space-filling curves resemble river networks or vascular systems.

Hilbert's curve was notorious because it profoundly disturbed conventional mathematical wisdom. Things without area should not be able to fill space. Some mathematicians built new theories on this pathology, while others recoiled in horror, entombing such curves in a "gallery of monsters." Mandelbrot resurrected these monsters and made them fundamental tools of science.

The monster metaphor persists to this day in the term "dragon." In 1960, physicist John E. Heighway described a remarkable space-filling curve generated by folding a long strip of paper in half over and over again and then opening the creases to right angles (see "A Tiger Meets a Dragon" by Dan Rollins, December 1983 BYTE). Its outline resembled that of a dragon (see figure 4), hence the dragon curve. Its resemblance to other fractals led to calling many fractals dragons.

Hunting for Dragons

A *dragon* is defined as an organism of cells arranged according to a genetic code. It begins life as a single cell and then, by daily cell division, grows into a creature with a shape and character governed by the DNA of its genetic code. The definition includes both regular fractals and space-filling curves. It is based on F. M. Dekking's notion of recurrent sets—a notion that had its origins in biologist A. Lindemayer's study of cell development. Lindemayer invented cellular automata to model cell behavior. One

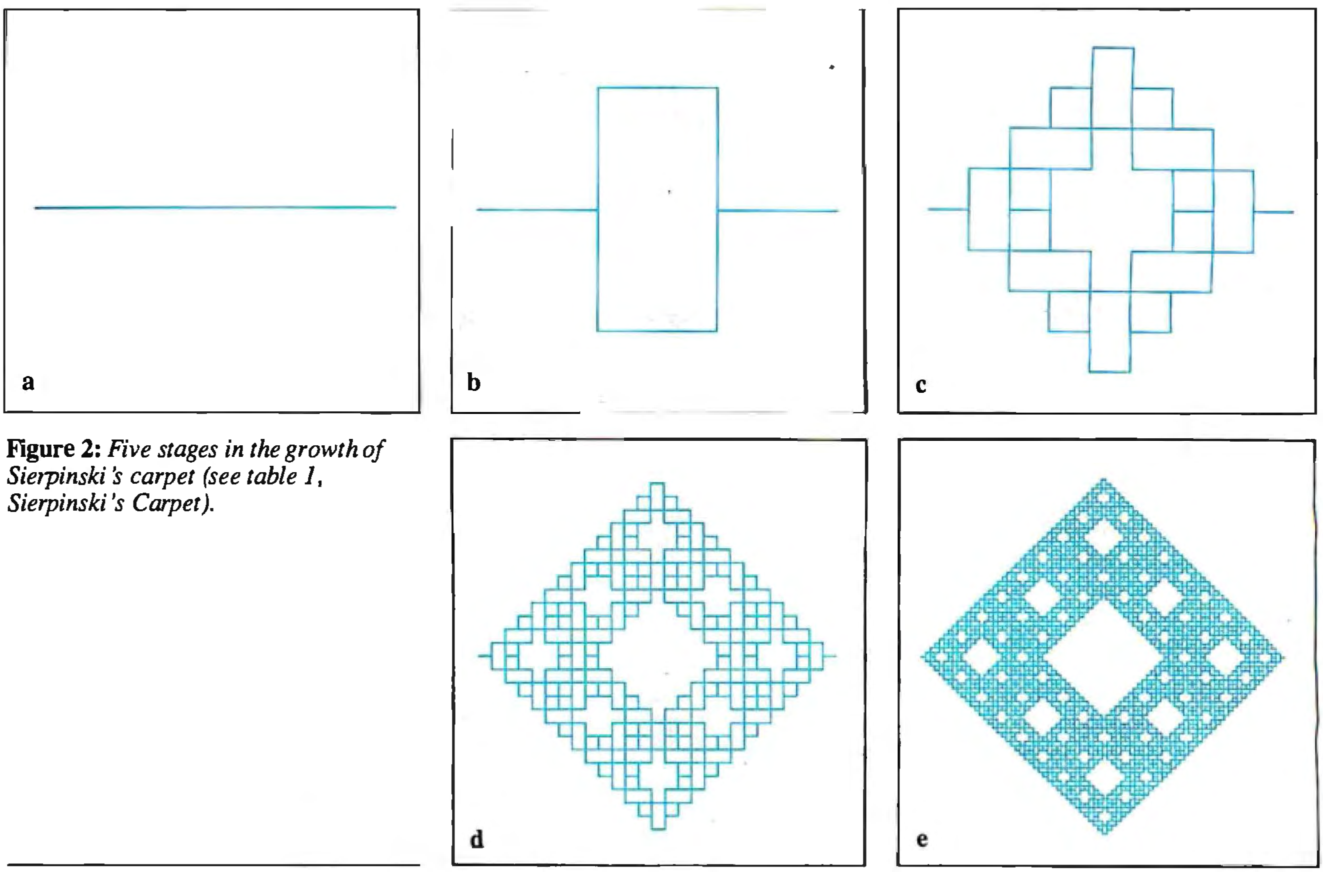

Figure 2: *Five stages in the growth of Sierpinski's carpet (see table 1, Sierpinski's Carpet).*

famous cellular automaton is Conway's game, Life.

The original example is Heighway's dragon. The first three days of its life are shown in figure 5. At birth (day zero), the dragon is composed of a single cell, a line segment. On day one, this cell divides into two cells, or line segments, at right angles. On day two, each of these cells divides into two cells at right angles for a total of four cells; the cell divisions alternate between lying first to the right and then to the left of the parent cell. This pattern of cell division continues each day of the dragon's life. Figure 4 shows Heighway's dragon after 10 days. Eventually, Heighway's dragon becomes a space-filling curve with a fractal outline.

The leftmost cell of Heighway's dragon is called the head cell. If you trace the dragon from head to tail, you will travel in four different directions. If the head cell is always oriented to the east, then the four directions traveled are east (E), north (N), west (W), and south (S). Since all the dragon's segments are equal in length, you can completely describe one day in the dragon's life with a record of directions.

For example, the record for day zero is E, day one is EN, day two is ENWN, and day three is ENWNWSWN. You can compute the record for the fourth day from that for the third day using the following table:

```
E -> EN
N -> WN
W -> WS
S -> ES
```

Each direction in day three translates into the two directions shown on day four. For example, the E on day three becomes EN on day four, the N translates to WN, and so on. Remarkably, these translations are sufficient to compute the record of any day in the life of Heighway's dragon from the previous day's record; thus, they are the genetic code, or DNA, of Heighway's dragon.

If you diagram the dragon starting with day zero, a tree-like structure results (see figure 6). Heighway's dragon has four cell types labeled E, N, W, and S to make the direction in which you traverse a cell part of its structure. To draw the dragon, you traverse the tree in the order shown by the broken arrow, drawing the cells at the bottom as you encounter them. You can use the same basic procedure to draw a different, arbitrary dragon.

Let a two-dimensional array *G* represent the genetic code, and *G(CELL,K)* stand for the *K*th cell in the division of *CELL*. If the one-dimensional array *I* interprets a cell geometrically, then

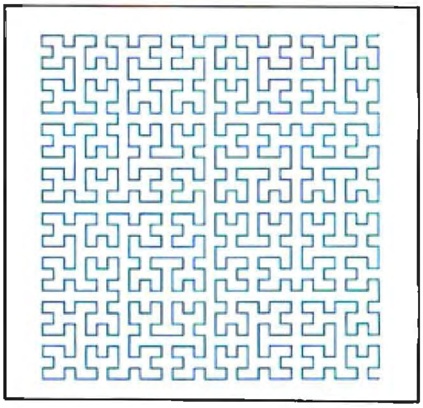

Figure 3: *Hilbert's curve, the most famous of the space-filling curves (see table 1, Hilbert's Curve).*

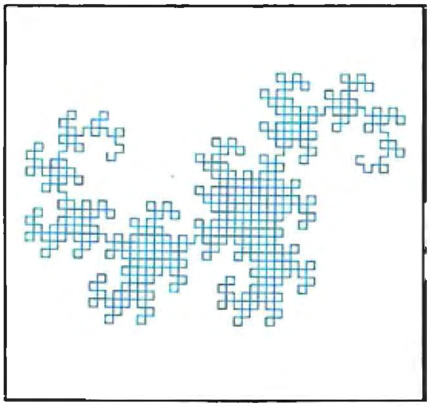

Figure 4: *Heighway's dragon after 10 days of life (see table 1, Heighway's Dragon).*

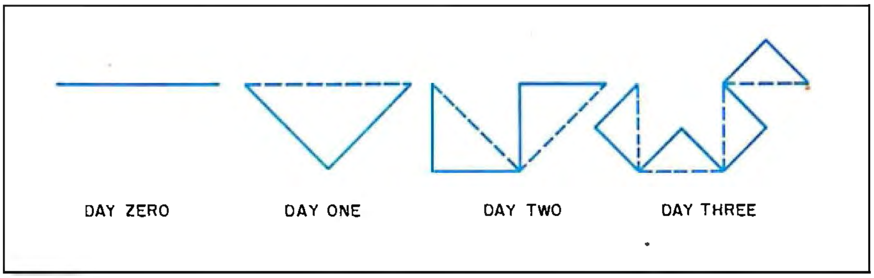

Figure 5: *The first three days in the life of Heighway's dragon.*

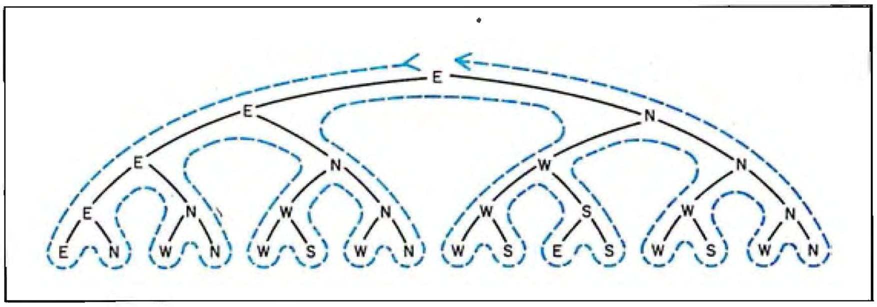

Figure 6: *The broken arrow shows how the procedure in listing 1 draws the cells at the bottom of the diagram in the order that it encounters them.*

I(CELL) points to the geometric object that corresponds to *CELL*. Listing 1 contains a recursive procedure that draws the *DAY*th day in a dragon's life starting with birth cell *CELL*.

If you want to draw a 10-day-old dragon with birth cell W, you enter its genetic code and interpreter into the *G* and *I* arrays, respectively, and execute the procedure in listing 1 for `DRAGON(10,W)`. The endless variety of shapes, including dragons, fractals, space-filling curves, and tree-like structures, occurs because you can choose the genetic code and the interpreter arbitrarily. The complexity that dragons exhibit occurs because the procedure is recursive.

Table 1 contains genetic codes and in-

continued

Listing 1: *A pseudocode procedure for drawing a dragon.*

```
DRAGON(DAY,CELL)
 if DAY=0 then
  draw I(CELL) starting from the
   current pen position
 else
  for K=1 to the number of cells
   into which CELL divides
   DRAGON(DAY-1,G(CELL,K))
  next K
end DRAGON
```

Table 1: *DRAGON.BAS data needed to create the fractals mentioned in this article.* D *is the number of directions,* M *is the number of cell types,* L *is the maximum number of next-generation cells into which a cell divides, and* I *is the interpreter value.*

Koch's Snowflake

D = 6
M = 6
L = 4
Cyclic
Standard

No.	Cell divisions	I
0	0 1 5 0	0
1	1 2 0 1	1
2	2 3 1 2	2
3	3 4 2 3	3
4	4 5 3 4	4
5	5 0 4 5	5

1 birth cell = 0
Days = 4
Length = 5
Coordinates = 100,180

Sierpinski's Carpet

D = 4
M = 8
L = 9
Cyclic
Not standard

No.	Cell divisions	I
0	0 1 0 3 6 3 0 1 0	0
1	1 2 1 0 7 0 1 2 1	1
2	2 3 2 1 4 1 2 3 2	2
3	3 0 3 2 5 2 3 0 3	3
4	4 4 4.	4
5	5 5 5.	5
6	6 6 6.	6
7	7 7 7.	7

1 birth cell = 0
Days = 3
Length = 5
Coordinates = 100,100

Sierpinski Again

D = 8
M = 8
L = 2
Not cyclic
Not standard

No.	Cell divisions	I
0	0 1	0
1	2 0	7
2	3 4	6
3	2 5	2
4	6 2	1
5	0 3	5
6	6 7	4
7	3 6	3

1 birth cell = 4
Days = 9
Length = 10
Coordinates = 200,90

Hilbert's Curve

D = 4
M = 10
L = 4
Not cyclic
Standard

No.	Cell divisions	I
0	1 0 3 4	0
1	0 1 2 5	1
2	0 1 2 6	2
3	1 0 3 7	3
4	6 7 4 0	0
5	7 6 5 1	1
6	7 6 5 2	2
7	6 7 4 3	3
8	1 0 3 9	.
9	6 7 4 8	.

1 birth cell = 8
Days = 5
Length = 5
Coordinates = 100,180

Gosper's Curve

D = 6
M = 12
L = 7
Cyclic
Standard

No.	Cell divisions	I
0	0 7 9 20011	0
1	1 8 10 3 1 1 6	1
2	2 9 11 4 2 2 7	2
3	3 10 6 5 3 3 8	3
4	4 11 7 0 4 4 9	4
5	5 6 8 1 5 5 10	5
6	5 6 6 8 3 1 6	0
7	0 7 7 9 4 2 7	1
8	1 8 8 10 5 3 8	2
9	2 9 9 11 0 4 9	3
10	3 10 10 6 1 5 10	4
11	4 11 11 7 2 0 11	5

3 birth cells = 0 4 2
Days = 3
Length = 3
Coordinates = 200,100

Random Curve

D = 8
M = 8
L = 2
Not cyclic
Standard

No.	Cell divisions	I
0	0 5	0
1	2 5	1
2	2 7	2
3	0 7	3
4	4 1	4
5	6 1	5
6	6 3	6
7	4 3	7

1 birth cell = 0
Days = 10
Length = 10
Coordinates = 200,20

Heighway's Dragon

D = 4
M = 4
L = 2
Not cyclic
Standard

No.	Cell divisions	I
0	0 1	0
1	2 1	1
2	2 3	2
3	0 3	3

1 birth cell = 0
Days = 9
Length = 5
Coordinates = 200,130

Heighway's Dragon Interior

D = 4
M = 8
L = 2
Not cyclic
Not standard

No.	Cell divisions	I
0	5 1	0
1	2 1	1
2	7 3	2
3	0 3	3
4	0 4	.
5	5 6	.
6	2 6	.
7	7 4	.

1 birth cell = 1
Days = 7
Length = 5
Coordinates = 200,150

Heighway's Dragon Boundary

D = 4
M = 12
L = 2
Not cyclic
Standard

No.	Cell divisions	I
0	0 5	0
1	6 9	1
2	7 2	2
3	11 4	3
4	8.	0
5	6.	1
6	10.	2
7	4.	3
8	0 1	0
9	10 9	1
10	3 2	2
11	11 8	3

4 birth cells = 0 5 6 11
Days = 5
Length = 8
Coordinates = 150,180

Heighway's Dragon Curd

D = 4
M = 8
L = 2
Not cyclic
Not standard

No.	Cell divisions	I
0	0 5	0
1	2 5	1
2	2 7	2
3	0 7	3
4	4 1	4
5	6 1	5
6	6 3	6
7	4 3	7

1 birth cell = 0
Days = 6
Length = 5
Coordinates = 200,80

Mandelbrot's Arrowhead

D = 6
M = 24
L = 3
Not cyclic
Standard

No.	Cell divisions	I
0	0 7 17	0
1	1 8 12	1
2	2 9 13	2
3	3 10 14	3
4	4 11 15	4
5	5 6 16	5
6	23 1 6	0
7	18 2 7	1
8	19 3 8	2
9	20 4 9	3
10	21 5 10	4
11	22 0 11	5
12	12 23 1	0
13	13 18 2	1
14	14 19 3	2
15	15 20 4	3
16	16 21 5	4
17	17 22 0	5
18	7 17 18	0
19	8 12 19	1
20	9 13 20	2
21	10 14 21	3
22	11 15 22	4
23	6 16 23	5

4 birth cells = 2 7 17 22
Days = 5
Length = 3
Coordinates = 200,180

Mandelbrot's Quintet

D = 4
M = 8
L = 5
Cyclic
Standard

No.	Cell divisions	I
0	4 0 3 6 3	0
1	5 1 0 7 0	1
2	6 2 1 4 1	2
3	7 3 2 5 2	3
4	7 2 7 4 0	0
5	4 3 4 5 1	1
6	5 0 5 6 2	2
7	6 1 6 7 3	3

1 birth cell = 0
Days = 4
Length = 5
Coordinates = 300,140

Brick Curve

D = 4
M = 6
L = 2
Not cyclic
Not standard

No.	Cell divisions	I
0	0 1	0
1	2 5	1
2	2 3	2
3	0 4	3
4	1 4	0
5	3 5	2

2 birth cells = 0 2
Days = 8
Length = 4
Coordinates = 225,100

Brick Interior

D = 4
M = 8
L = 2
Not cyclic
Not standard

No.	Cell divisions	I
0	0 1	.
1	2 6	.
2	2 3	.
3	0 4	.
4	5 4	0
5	2 6	1
6	7 6	2
7	0 4	3

1 birth cell = 0
Days = 8
Length = 5
Coordinates = 200,100

Davis and Knuth's Terdragon

D = 3
M = 3
L = 3
Cyclic
Standard

No.	Cell divisions	I
0	0 1 0	0
1	1 2 1	1
2	2 0 2	2

1 birth cell = 0
Days = 6
Length = 7
Coordinates = 350,100

Pentigree Curve

D = 5
M = 5
L = 6
Cyclic
Standard

No.	Cell divisions	I
0	0 4 1 2 1 0	0
1	1 0 2 3 2 1	1
2	2 1 3 4 3 2	2
3	3 2 4 0 4 3	3
4	4 3 0 1 0 4	4

1 birth cell = 0
Days = 4
Length = 4
Coordinates = 350,180

Moore's Necklace

D = 4
M = 8
L = 9
Cyclic
Standard

No.	Cell divisions	I
0	0 1 2 6 2 3 7 6 5	0
1	1 2 3 7 3 0 4 7 6	1
2	2 3 0 4 0 1 5 4 7	2
3	3 0 1 5 1 2 6 5 4	3
4	1 2 3 7 6 2 6 5 4	0
5	2 3 0 4 7 3 7 6 5	1
6	3 0 1 5 4 0 4 7 6	2
7	0 1 2 6 5 1 5 4 7	3

1 birth cell = 0
Days = 3
Length = 5
Coordinates = 300,100

Dekking's Church

D = 4
M = 4
L = 4
Not cyclic
Standard

No.	Cell divisions	I
0	0 1 0 3	0
1	2 3 2 3	1
2	2 1 .	2
3	0 1 .	3

4 birth cells = 0 3 2 1
Days = 5
Length = 5
Coordinates = 100,150

Lace Curve

D = 12
M = 24
L = 3
Not cyclic
Not standard

No.	Cell divisions	I
0	0 1 2	2
1	3 4 5	4
2	6 7 0	1
3	1 8 9	10
4	10 11 12	0
5	7 0 1	11
6	8 13 14	10
7	15 10 16	0
8	6 7 17	6
9	11 18 3	5
10	4 15 19	4
11	13 6 20	6
12	18 3 4	3
13	11 18 21	8
14	8 13 6	5
15	7 0 22	2
16	13 6 7	3
17	0 1 8	9
18	18 3 23	8
19	4 15 10	11
20	15 10 11	9
21	1 8 13	7
22	3 4 15	1
23	10 11 18	7

3 birth cells = 10 11 18
Days = 5
Length = 5
Coordinates = 200,100

Christmas Tree

D = 5
M = 10
L = 3
Cyclic
Standard

No.	Cell divisions	I
0	9 0 6	0
1	5 1 7	1
2	6 2 8	2
3	7 3 9	3
4	8 4 5	4
5	1 5 4	0
6	2 6 0	1
7	3 7 1	2
8	4 8 2	3
9	0 9 3	4

1 birth cell = 5
Days = 6
Length = 5
Coordinates = 200,150

Slaying the Dragon

First, choose the dragon you want to create from the list of inputs in table 1. Load Microsoft BASIC, then load and run DRAGON.BAS. The program will ask you if you want to load a dragon from disk. Initially, the disk will contain no dragons, so press the Return key. (If this is not your first run and you do have dragons on disk, type the desired dragon's name without the .CRV extension followed by a Return.)

Then Dragon asks you for the number of directions, D, you want to use. (Dragon assigns each cell an integer from 0 to $M-1$, where M is the number of cell types and each cell is a vector in one of D directions, the Ith direction pointing $360I/D$ degrees, measured counterclockwise from east.) Enter the number shown for D under the dragon you want to create in table 1.

Next, Dragon asks for the number of cells, M. Then, it wants to know the maximum number of next-level cells into which a cell may divide, so that it can dimension the genetic code array large enough to hold all cell divisions. (Let L be the maximum number of next-generation cells into which a cell divides. Then the genetic-code array is an M by $L+1$ array, where the first position in a row holds the number of next-generation cells into which the cell corresponding to that row divides.)

Then, the program asks if the dragon you are creating is cyclic. If it is, press Return; if it is not (or you want to ignore the request), press any key other than Return (a space, for instance). A dragon is cyclic if its genetic code has a cyclic pattern, which makes the division of a cell labeled $ID+R$ where ($0 <= R < D$) is determined by the division of the cell labeled ID. If the dragon is cyclic, the program will request the division of only those cells labeled a multiple of D (equal to the number of directions) and compute the remaining cell divisions. If the dragon is not cyclic, the program will request the division of each cell, one by one.

Table 1 contains the cell divisions for all cells. The left-hand number is the cell number for reference only; the right-hand numbers are the cell divisions and should be entered in order, each followed by a Return. If the row appears incomplete and includes a period, for example, 4., that is an internal indicator that tells the program that 4 is the last cell in that division. The cell should be entered as 4. followed by Return.

Dragon now wants the interpreter array, I, which tells the program which vector to draw, move, or do nothing for each cell type. Dragon first wants to know if the interpreter array is standard. It asks if the cell directions are "cell modulo number of directions," that is, if the interpreter value of a cell is its remainder when divided by D. The interpreter value determines the direction in which a particular cell is to be drawn. Most of the interpreter arrays for the dragons in table 1 are standard. If the dragon you are drawing is standard, press Return. If not, enter the values listed for that dragon under I in table 1.

Acceptable interpreter values are integers from -1 through $2D-1$. The value -1 means the corresponding cell is a "do-nothing" cell, a value of I between 0 and $D-1$ means the corresponding cell is drawn in the direction $360I/D$ degrees, and a value of I between D and $2D-1$ means the corresponding cell is "invisible" and the pen merely moves in the direction $360I/D$ degrees. Heighway's Dragon Curd (see figure A) in table 1 has 8 cells, 0 through 3 visible and 4 through 7 invisible. Each divides into two cells, one visible and one invisible.

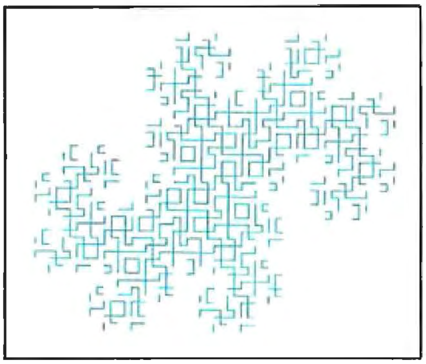

Figure A: *A fragmented dragon with "invisible" cells (see table 1, Heighway's Dragon Curd).*

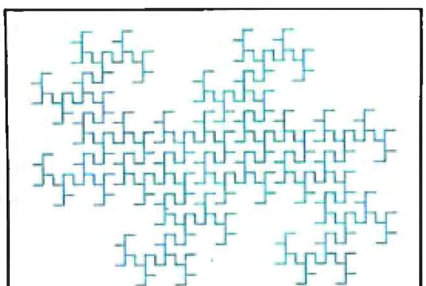

Figure B: *A dragon using do-nothing cells (see table 1, Heighway's Dragon Interior).*

If you want a cell to have no substance (i.e., do nothing except produce offspring), enter a period for its interpreter value (the program converts periods to -1s). Heighway's Dragon Interior (see figure B) in table 1 is an example in which ghostly do-nothing cells eventually have material descendants.

Dragon now asks how many birth cells there are. It will draw one dragon for each birth cell you give it. Enter the number of birth cells, and then, in order, their cell numbers, each followed by Return.

Next, the program asks for the dragon's age in days, and the cell length. Finally, it needs the x and y coordinates of the location on the screen to begin the drawing (separated by Returns).

When the program finishes drawing the dragon, it displays a menu of options. The first option permits redrawing the current dragon with a new set of drawing parameters, the second keeps the birth cells but allows the other parameters to change, and the third permits saving the dragon (without the birth cells) to disk. (These option numbers do *not* need to be followed by a Return.) Whatever filename you give the dragon, if you wish to save it, will have a .CRV suffix appended to it. Any other key pressed (except the Break key) returns you to the beginning of the program.

Where No Man Has Gone Before

The age, length, and coordinates given will draw a dragon contained entirely on the display of a 640- by 200-pixel monochrome screen. These are the variables you will want to vary to play with the dragon. What happens if the dragon is a bit older or younger? What does it look like with longer or shorter line segments? What is its best starting position on your screen? You may also want to add color to the program, changing colors between dragon segments.

Experimenting with the dragons given here by giving different ages, different length lines, interspersing do-nothing cells, and changing birth cells will give you a feel for finding your own. Many of the possible combinations and permutations won't give you interesting dragons, but when you find one that is both interesting and new, the excitement is as close as many of us will ever come to discovering new worlds.

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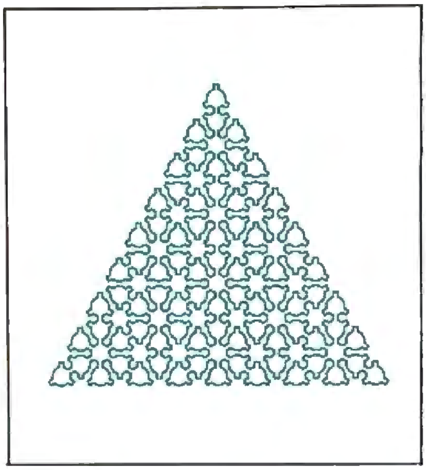

Figure 7: *A lace-like curve (see table 1, Lace Curve).*

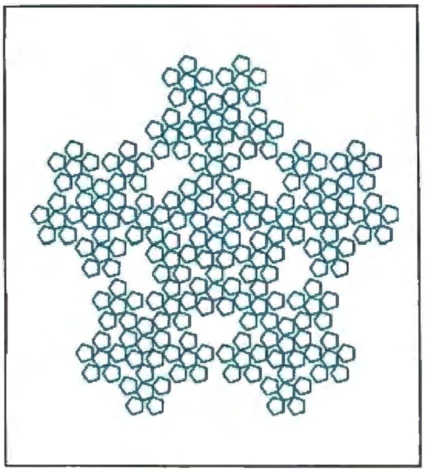

Figure 8: *Pentigree, an accidental discovery (see table 1, Pentigree Curve).*

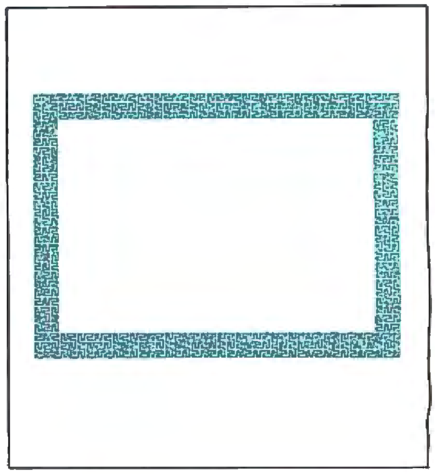

Figure 9: *Moore's necklace formed from 44 copies of a two-day-old dragon (see table 1, Moore's Necklace).*

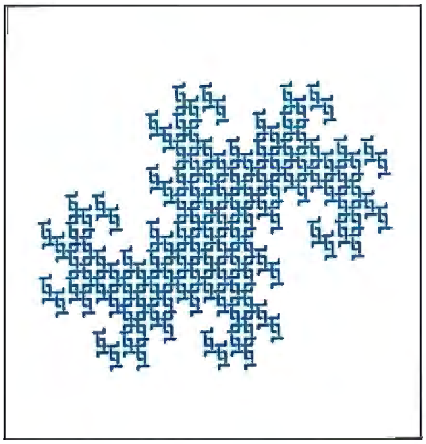

Figure 10: *A twindragon using L-shaped cells.*

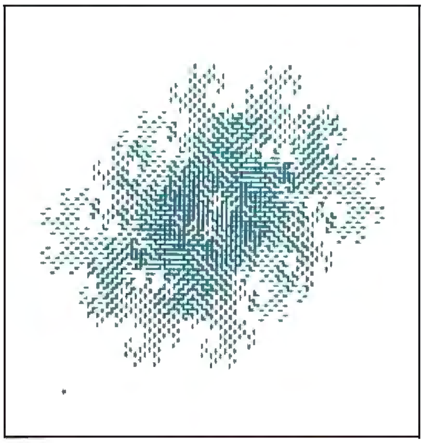

Figure 11: *An exploded twindragon using line segments, each displaced from where it belongs.*

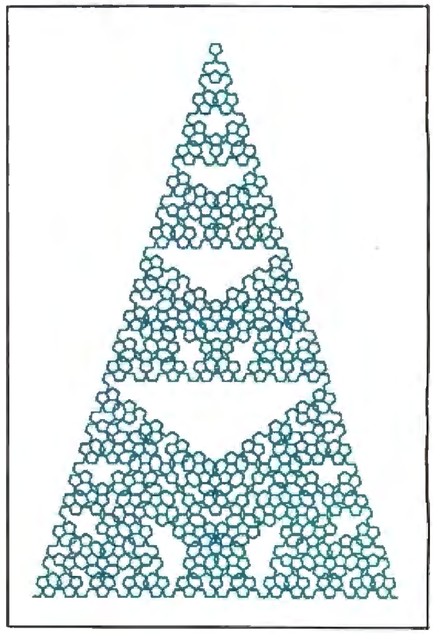

Figure 12: *A Christmas-tree dragon (see table 1, Christmas Tree).* ▶

terpreters for some well-known and some new dragons, including space-fillers like Hilbert's Curve, Sierpinski's Carpet, Davis and Knuth's Terdragon, Mandelbrot's Quintet, Gosper's Curve, and a lace-like curve I found (see figure 7). Some true fractals are Koch's Snowflake, Mandelbrot's Arrowhead, a happy accident I call the Pentigree (see figure 8); and some other dragons that a graphic artist might use to simulate river networks or gnarled trees (see figure 9).

The program DRAGON.BAS draws dragons on the display whose cells are composed of equal-length line segments confined to a two-dimensional plane. (Listing 1 imposes no restrictions on the dimension of the space in which a dragon lies. It can also draw Milne's cube-filling curve.) In addition, Dragon provides the ability to draw fragmented dragons—Mandelbrot calls them *dusts* or *curds*—made of more than one curve by making cells of your choosing "invisible" (see figure A). With the use of "do-nothing" cells that set up for the next day but don't do anything else, the program can draw some very subtle dragons (figure B). (For details on using Dragon, see the text box, "Slaying the Dragon," on page 128.) [*Editor's note: DRAGON.BAS is available in Microsoft BASIC source code for the IBM PC and its compatibles. An improved version, QDRAGON.BAS, in QuickBASIC, is also available along with instructions for its use, QRULES.TXT, and data files for various fractals, denoted by .CRV suffix. These files are available on disk, in print, and on BIX; see the insert card following page 256 for details. They are also available on BYTEnet; see page 4.*]

Copies of a dragon strung together can have interesting effects. Figure 9 shows Moore's necklace, 44 copies of a two-day-old dragon forming a border design. The program permits drawing strings of dragons. The twindragon is two copies of Heighway's dragon, belly to belly. In Dragon, you would enter birth cells 0 and 2, which represent the two cells that begin the two dragons. Dekking's church is a closed loop of four dragons with birth cells 0, 3, 2, and 1. The pentigree in figure 8 is a loop of five dragons, birth cells 0, 4, 3, 2, and 1.

A more subtle texturing scheme credited to Vic Norton can enrich almost any dragon. Instead of making cells line segments (as the program does), you can make them arbitrary pictures. Figures 10 and 11 show two twindragons with modi-

continued

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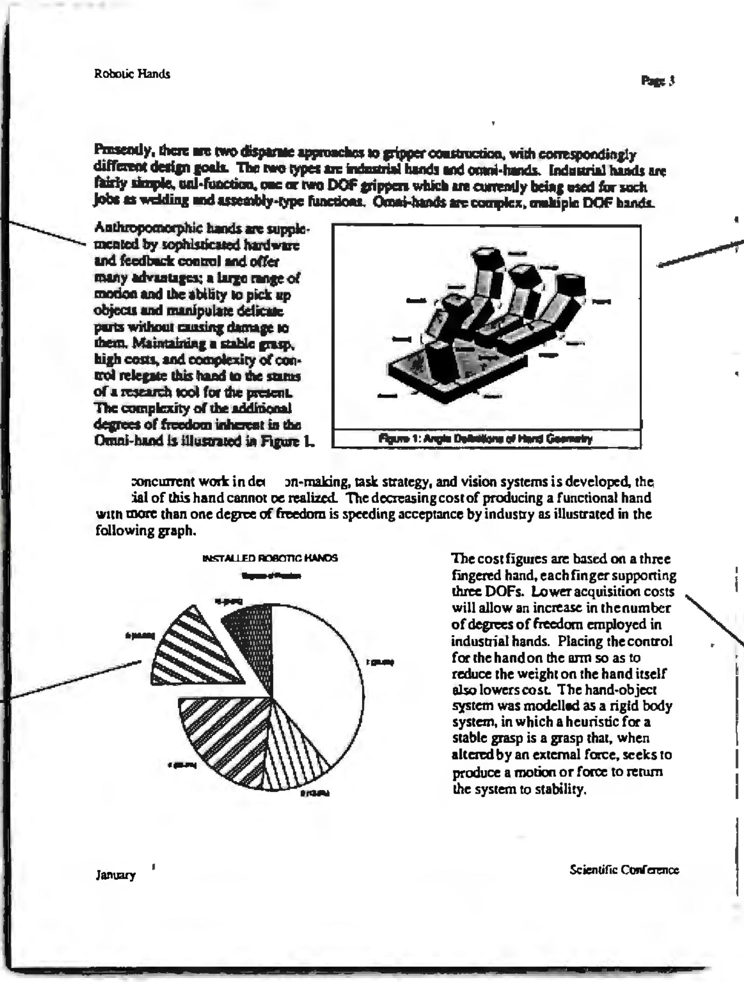

Robotic Hands

Page 3

Presently, there are two disparate approaches to gripper construction, with correspondingly different design goals. The two types are industrial hands and omni-hands. Industrial hands are fairly simple, uni-function, one or two DOF grippers which are currently being used for such jobs as welding and assembly-type functions. Omni-hands are complex, multiple DOF hands.

Anthropomorphic hands are supplemented by sophisticated hardware and feedback control and offer many advantages; a large range of motion and the ability to pick up objects and manipulate delicate parts without causing damage to them. Maintaining a stable grasp, high costs, and complexity of control relegate this hand to the status of a research tool for the present. The complexity of the additional degrees of freedom inherent in the Omni-hand is illustrated in Figure 1.

Figure 1: Angle Definitions of Hand Geometry

concurrent work in de on-making, task strategy, and vision systems is developed, the ial of this hand cannot be realized. The decreasing cost of producing a functional hand with more than one degree of freedom is speeding acceptance by industry as illustrated in the following graph.

INSTALLED ROBOTIC HANDS

The cost figures are based on a three fingered hand, each finger supporting three DOFs. Lower acquisition costs will allow an increase in the number of degrees of freedom employed in industrial hands. Placing the control for the hand on the arm so as to reduce the weight on the hand itself also lowers cost. The hand-object system was modelled as a rigid body system, in which a heuristic for a stable grasp is a grasp that, when altered by an external force, seeks to produce a motion or force to return the system to stability.

January

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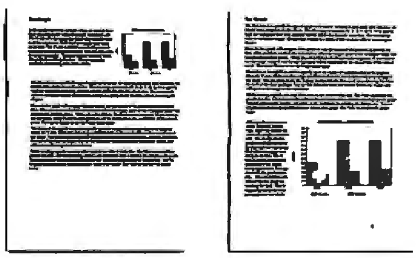

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fied cells. Figure 10 has L-shaped cells positioned so that the figure is reminiscent of the chain-mail armor worn by ancient warriors. While figure 11's cells are still single line segments, each is displaced some distance away from where it belongs, resulting in fractalized abstract art. It is not difficult to modify Dragon to interpret each cell as a pattern rather than as a line segment.

Endless Possibilities

You can discover entirely new dragons by accident. Just enter any genetic code and interpreter that come to mind. The resulting dragon will be a sprawling snake, a clumsy creature forever stumbling over itself, or something quite nice.

When Dr. McWorter began exploring dragons, he had no construction schemes, so he conducted a more or less random search. Most of the interesting dragons he found were already known. One new dragon crosses and retraces itself repeatedly, resembling a decorated Christmas tree (see figure 12). He discovered it using a paper-folding scheme suggested by that for Heighway's dragon. Another dragon he stumbled on, which does not cross itself, is the pentigree in figure 8. It has a filigree pattern that eventually makes it a true fractal; the holes reduce its Hausdorff dimension to slightly less than 2.

From imitating or modeling nature to creating fantastic dragons, the possible combinations of computations and permutations that will create a fractal are literally endless. The examples given here only scratch the surface of what is possible for dragons in two-dimensional space, to say nothing of other dimensions. Systematic methods for inventing dragons with a given character have also been developed (see A. Cobham and F. M. Dekking in bibliography). Experimenting with Dragon will provide some clues to these methods, as will exploring Mandelbrot's books.

The procedure outlined here is not limited to two-dimensional fractals or to cells that are line segments of fixed length. You can code the procedure to draw three-dimensional images of dragons that live in three-dimensional space, modify it to permit variable-length cells, or extend it to draw Escher patterns or more abstract creations.

Once you begin to experiment with fractals, it is difficult to stop. Running Dragon is a special delight. Seeing a completed dragon can't compare to the thrill of watching it being drawn. And it's hard to resist the temptation to see what "this one little change" will do as you explore these fascinating creatures. ■

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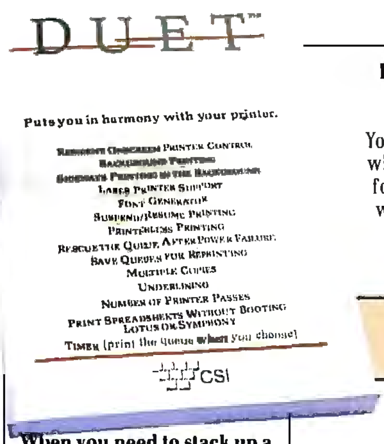

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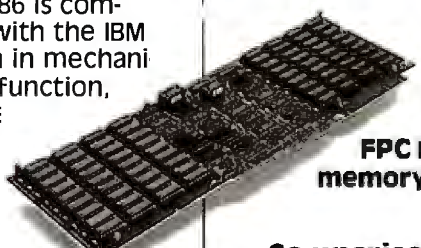

FPC MEM2M memory board

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PARALLEL PORT	1	1
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MEMORY	512 K on Board	2 mB Memory Bd as a standard
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Bill Nicholls

Inside the 82786 Graphics Chip

Intel's graphics coprocessor features silicon window support

Intel's 82786 graphics processor is another step in the continuing conflict between the demand for higher resolution, more colors, and faster display. By improving the performance of current programs, such as Microsoft's Windows or Digital Research's GEM, it gives users more flexibility with the programs they already have. And by expanding display speed and resolution, it gives software developers more latitude in designing new systems.

Intel defines 82786 windows as "portions of bit maps . . . output by the display processor." The 82786 can display a large number of windows simultaneously. It can have up to 16 horizontal window segments on any single scan line, and as many vertical window segments as there are scan lines.

With the system clock running at 10 megahertz and the video clock at 25 MHz, the 82786 executes line draws at 2.5 million pixels per second, circles at 2 MPS, and area fills at 30 million bits per second.

The graphics coprocessor's bus interface does bus block transfers (BBLTs) at 24 million bps and draws 25,000 characters per second regardless of font or orientation. Internal hardware handles character fonts up to 16 by 16 pixels. Larger fonts require both software and hardware, or BBLT transfers.

The 82786 can perform vertical and horizontal scrolling immediately, without external hardware, and enlarge (zoom) up to 64 times in either direction (in this case, zoom is a pixel-replication function).

The 82786 internal graphics processor and display processor each use 22 address bits, yielding an address range of 4 megabytes shared by the host processor and the graphics display processor. The 82786 can display up to 1024 colors simultaneously and supports resolutions of from 640 by 480 pixels by 8 bits, to 1024 by 1024 pixels by 2 bits with 60-Hz noninterlaced refresh.

By using video RAMs, you can boost resolution to 2048 by 1536 pixels by 8 bits, up to a maximum of 4096 by 4096 pixels by 1 bit. In addition, you can synchronize multiple 82786 chips to produce higher-performance systems with more colors, higher resolution, and greater bandwidth.

Graphics Coprocessor Architecture

The principal components of the 82786 graphics coprocessor architecture are the graphics processor, display processor, bus interface, RAM refresh unit, and graphics memory space (see figure 1). The graphics processor executes instructions placed in RAM by the host CPU and updates the bit map in graphics memory for the display processor.

The display processor transforms the bit maps created by the graphics processor into the raster sequences required by the system display. The bus interface comprises four logical interfaces: external, memory access for the graphics processor, host-processor access to processor registers and graphics memory, graphics-processor access to the graphics memory, and requests for video RAM refresh.

The Graphics Processor

The graphics processor executes linked lists of graphics commands residing in the host processor's memory, accessing them via the bus-interface logic. The host processor first builds the list of graphics instructions and their parameters. Then, the host processor initializes the graphics processor by writing the upper and lower bytes of the link address in the graphics processor's control register and setting the link-command bit.

After a reset, the graphics processor starts up in poll mode and checks the value of bit 0 (the end-of-instruction-list flag) of its instruction register. When the host processor loads an instruction that has bit 0 cleared, the graphics processor begins executing instructions, starting with a link address to the beginning of an instruction list in memory.

Once started by the host processor, the graphics processor executes instructions without being synchronized to either the host processor or the display processor. The host processor can write graphics-processor instructions anywhere in the graphics processor's 4-megabyte address space.

Pixel drawing is done in the graphics memory only. The graphics processor can update bits in any bit map in the graphics memory, regardless of whether the display processor is actively displaying that bit map.

The graphics processor can also operate in pick mode. Instead of updating the graphics memory, the graphics processor executes the instructions and checks to see if the pixels they address are in the clipping window defined in the window descriptor block (see the text box, "Managing Windows," on page 137). If these objects are within the clipping window, a flag is set to speed up the selection of objects on the screen.

continued

Bill Nicholls is the owner of BGW Systems Inc., a small-business and personal computer software company. You can contact him there at 16714 Meridian S, Suite 200, Puyallup, WA 98373. He holds a B.S. in physics from the University of Notre Dame.

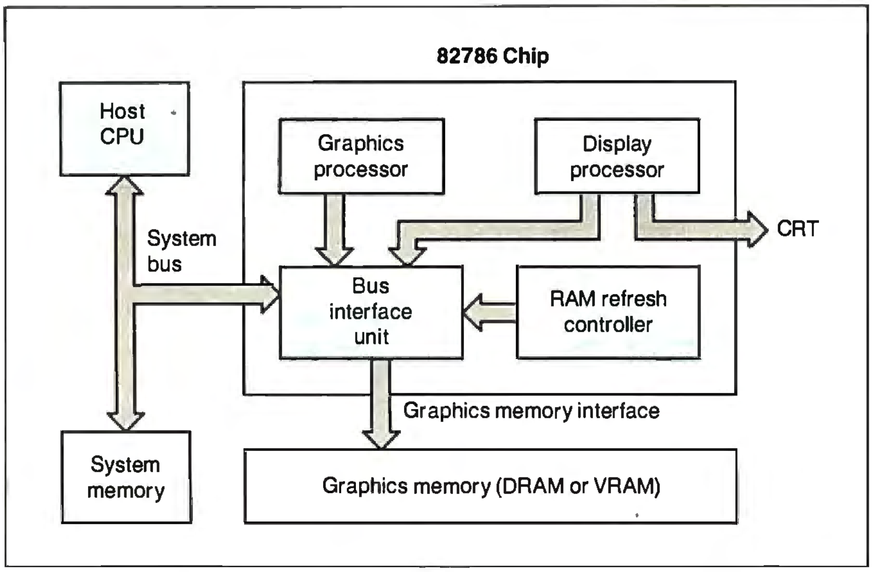

Figure 1: *The 82786 graphics coprocessor architecture.*

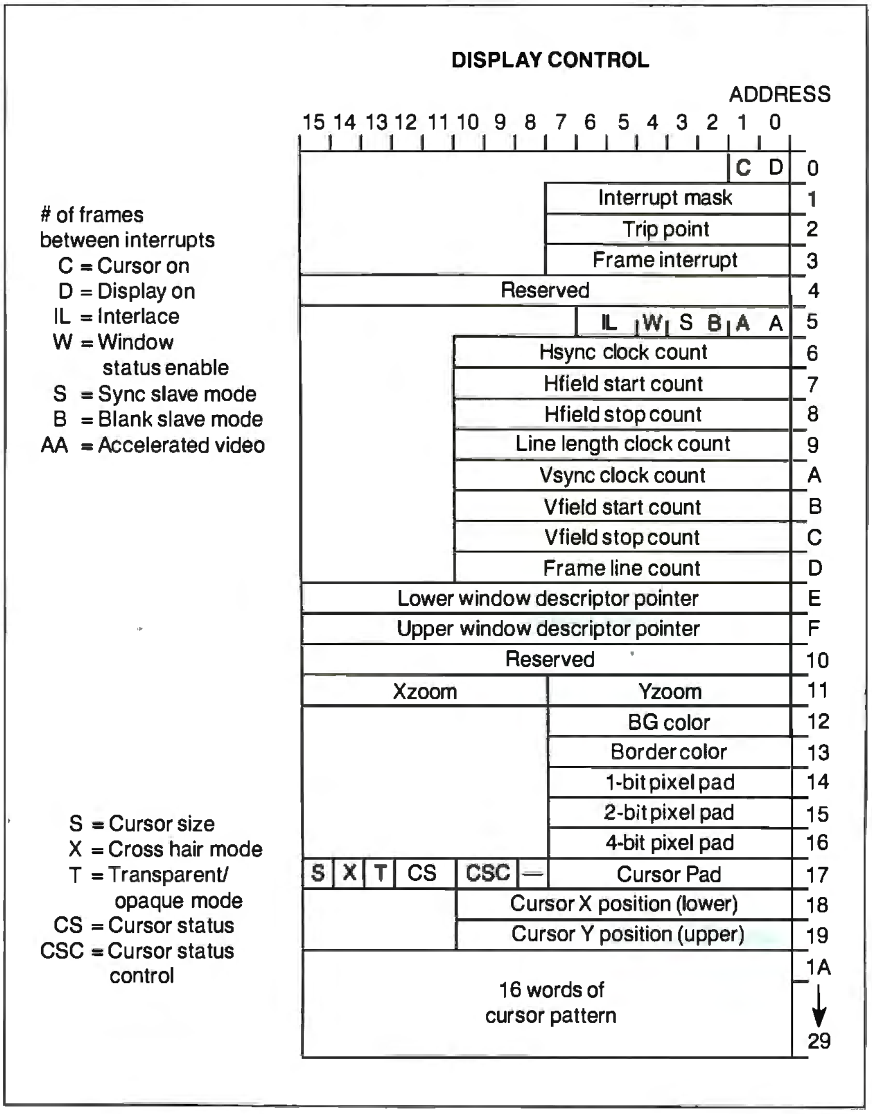

Figure 2: *Graphics coprocessor display-control block.*

The Display Processor

The display processor controls the pixel output to a CRT, laser printer, or other raster output device. The display processor transforms the bit map created by the graphics processor into the sequence of pixels and control signals required for the attached device. The display processor is optimized for data in packed bit-map form but can switch while in a window to IBM Color Graphics Adapter mode and byte-swapped addressing. You can also synchronize the display processor to external video sources.

Program instructions also drive the display processor, but in a unique fashion. Once for each frame, the display processor can load a new instruction into its registers for execution during the following frame. This highly complex instruction specifies everything except the windows on the screen. The instruction (see figure 2) points to another block of memory, which specifies the windows. The program parameters specify functions such as hardware zoom, cursor display, windows, video pixel rates, and CRT timing signals.

The display processor can zoom the display screen horizontally and vertically by a factor of from 1 to 64, affecting all windows. (This is a pixel-replication function, as opposed to recalculating endpoints and redrawing lines.) At the normal video rate of 25 MHz and 8 bits per pixel, you can locate windows on the screen with single-pixel resolution. You can set the cursor to display as 8 by 8 or 16 by 16 pixels with single-pixel resolution.

The cursor can be opaque, transparent, a block, or full-screen cross hairs. You can program cursor color, pattern, and blinking, and turn off the cursor. CRT timing signals are programmed at single-pixel resolution, allowing up to 4096- by 4096-pixel displays.

You can change the display processor's mode to trade off bits per pixel for pixel draw rate. Thus, you can exchange the basic 25 MHz at 8 bits per pixel for 50 MHz at 4 bits per pixel, 100 MHz at 2 bits per pixel, or 200 MHz at 1 bit per pixel. At the higher rates, horizontal resolution decreases to 2-, 4-, or 8-pixel boundaries.

The display processor controls the video RAMs by loading the shift registers during the retrace time between each scan line. Additional processing is required for each display line containing windows or cursor display before the line loading into the VRAM shift register.

Memory-Access Priorities

The bus-interface logic performs arbitration between four logical interfaces: ex-

Managing Windows

Most of the effort in programming the display processor involves setting the window strip descriptors as windows are moved and overlaid. The host processor must determine which windows are visible on the screen, in what order they appear vertically, and in what sequence they appear horizontally. From this information, the host processor builds one or more linked window-strip descriptors that specify how to display each window segment or "tile" (see figure A). Descriptors for each strip link together in a list forming a complete description of the screen in tile-by-tile sequence. Since the list is linked, you can update it on the fly if you're careful.

The window descriptor block shows a display header and multiple tile descriptors, organized in the sequence in which they will appear on screen. Each tile is a horizontal segment of a window that is not obstructed on the display. A tile can be anything from a scan line to a full window in height, and from one pixel to the full screen in width. The only limitation is that there can be no more than 16 tiles per scan line. Each tile can specify a separate bit map, bits per pixel, and several other window parameters.

The display processor ties its execution of instructions to the display's refresh rate. During the vertical-blanking interval, the display processor will load a new command into an internal control block (if its control registers point to one). The internal control block is not directly accessible; it is loaded or stored by instructions in a six-register section of the main graphics-coprocessor registers. Display-processor commands generate external signals for horizontal and vertical timing, blanking signals, and the chip's eight video output pins. Internally, it controls interlace, synchronization, window and cursor generation, colors, and pixel bit-padding.

During each frame, the display processor executes the command (actually a macroinstruction) contained in the 42-word internal control block and a variable-length window descriptor block. It can execute only one command during the frame, which prevents interference with display refresh. Under control of the parameters set in the control and window blocks, the display processor

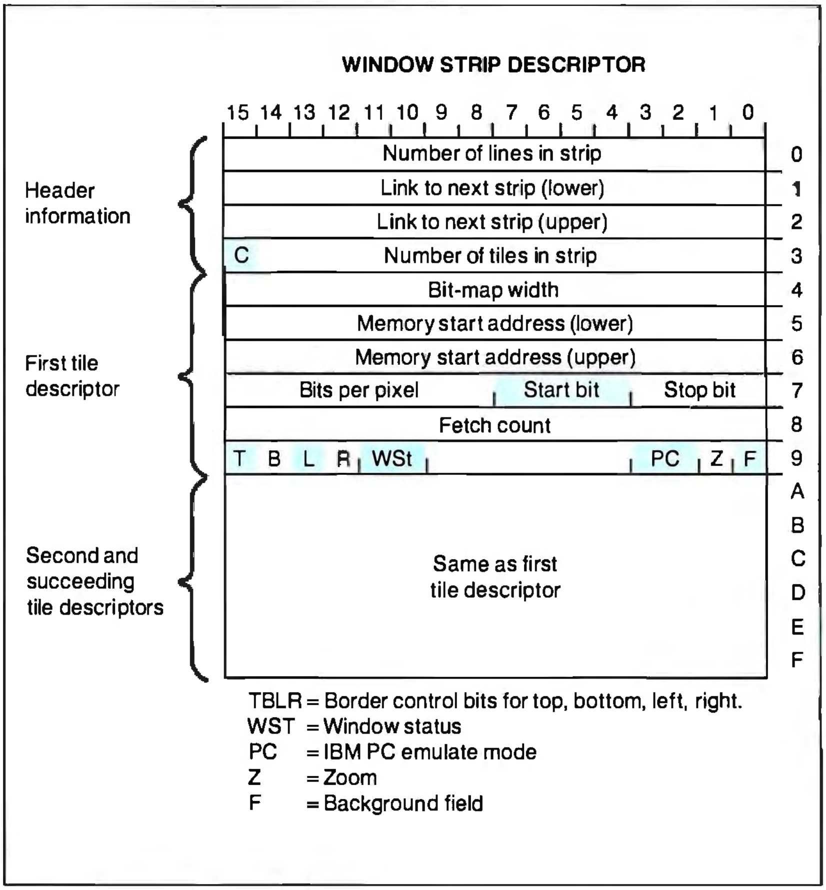

Figure A: *Graphics coprocessor window-descriptor block.*

retrieves portions of one or more bit maps from graphics memory and outputs them to the display as pixels.

This process is somewhat complex. Here's how it works: The display processor fetches the window-strip-descriptor header for the first set of tiles.

Using the tile count, the display processor then loads the first tile descriptor, which contains the pointers to the actual memory containing the image and the dynamic window parameters. The display processor then builds the pixel output from the specified memory areas until the tile (created by this tile descriptor) is completed.

The display processor then links to the next window-strip descriptor (the first header specifies the link), and it repeats this process until all the tiles comprising the screen have been built. The display processor can then load a new macroinstruction at vertical-retrace time and begin the process of creating the next screen.

While the display processor is busy displaying a screen of windows, the graphics processor can update images and the host processor can set up new windows for display. The new set of windows is linked by the macroinstruction, or a link to a new set of window strip descriptors.

The cost of all these capabilities is the significant amount of programming required. Streamlining this process will require new parameter sets that control the 82786 to avoid reinventing fast-line drawing. The 82786 represents a functional step upward, but it will take a little time for the programmers to take full advantage of this added capability.

ternal host memory access for the 82786, host-processor access to internal registers and graphics memory, 82786 access to graphics memory, and, most importantly, RAM refresh.

The refresh unit generates and queues RAM refresh requests to the bus interface, which executes them at top priority. The host processor, graphics processor, and display processor contend for memory access according to a 3-bit priority system.

The priorities break down further into first access (FA) and subsequent access

continued

(SA). Default priorities are (high to low) RAM refresh, display processor, graphics processor, and host processor. RAM refresh is always the highest priority, but you can change the others under program control. This allows you to program performance trade-offs into the chip to take advantage of the 82786 for various types of applications.

The default priorities after a reset are Host (FA) 7, Display (FA) 6, Graphics (FA) 5, Display (SA) 3, and Graphics (SA) 2. Since the graphics processor and display processor usually access more than one word in sequence, the bus interface provides maximum throughput when accessing sequential words. However, if sequential access locks out a first access from another processor, that might affect overall performance.

This adjustable priority scheme lets software maximize the 82786's performance for specific circumstances by balancing access priority of the host processor, graphics processor, and display processor in relation to their need for first and sequential access.

The refresh-controller parameters, which the software sets at start-up, schedule the DRAM refresh, although the bus interface unit performs the actual refresh cycles. Because of the contention for graphics memory access, you can queue three refresh requests internally. The longest acceptable delay without refresh is 225 cycles at 10 MHz (about 45 microseconds).

Manipulating Bit Maps

The graphics processor converts host-processor graphics commands into a specific bit representation as specified by the drawing parameters contained in the graphics-processor instructions. The instruction-execution process starts by loading the graphics processor's link address registers (upper and lower byte) with an address that points to the beginning of a list of instructions. The graphics processor executes instructions until stopped by a flag (bit 0 set to 1) in an instruction word.

During its execution, the graphics processor shares memory access (with the display processor and host processor) to the 4-megabyte address space. The bus-interface logic controls this sharing according to parameters set by the host processor at start-up.

The graphics processor draws a bit map into graphics memory. You can think of this bit map as a rectangular array of display pixels (up to 32K by 32K pixels in size) with the (0,0) coordinate located at the display's upper left corner. Pixels are packed linearly in the bit map.

The system stores 4-bit pixels as four

pixels per 16-bit word, each line consisting of (the number of pixels divided by four) words, with the lines stored sequentially. Thus, the bit map is packed into the minimum memory required for a given display size and number of bits per pixel.

Graphics-processor performance depends heavily on frequent access to graphics memory. Ignoring the overhead for instructions, each updated word requires a read-modify-write (RMW) cycle of graphics memory. An 8-bit-per-pixel resolution requires a word access for every two pixels.

The two predominate factors affecting performance are graphics-memory bandwidth and the amount of display-processor overhead involved in an operation. If you use VRAMs, the graphics processor will be able to use up to 99 percent of the available memory-bus bandwidth. Using DRAMs, the memory bandwidth available to the graphics processor depends upon the access required by the display processor and can be from 50 percent to 90 percent.

Graphics Memory

One of the 82786's key high-performance graphics features is its dynamic-memory interface. This interface lets the 82786 take full advantage of both dual-bank and page modes of using dynamic RAMs for a maximum speed of 40 megabytes per second.

The 4-megabyte linear address space of the graphics processor begins at address 00 hexadecimal of the graphics memory. If less than 4 megabytes of graphics memory is implemented, the remaining addresses access system memory (see figure 3). You can move these system addresses by setting the top 2 address bits externally to point anywhere in the host processor's 4-megabyte address space.

The 82786 was designed to support a wide range of DRAM configurations: one or two banks for interleaving with one to four rows per bank; 16K-bit to 1-megabit RAMs in by-1, by-4 and by-8 width; and page or fast-page modes for performance. (Fast-page-mode RAMs can be cycled in 100 nanoseconds instead of the 200 ns required for page-mode RAMs.)

The memory interface will support up to 32 DRAMs without external logic, within the total 4-megabyte addressable memory.

The 82786 can also use video RAMs in its overall memory scheme. VRAMs contain a shift register and a serial output that allows high-speed shifting of the video data without repeated memory ac-

continued

cess. The use of VRAMs for graphics memory decreases the display overhead from a maximum of 50 percent to approximately 1 percent.

Using VRAMs makes more memory cycles available for the host and graphics processors, but some features are restricted.

The 82786 can zoom VRAM-supported displays vertically, but horizontal zoom requires external circuitry because the 82786 doesn't have access to the bit map to replicate the pixels once the bit map has been moved into the shift register.

The DRAM access can be single or multiple cycle. A single cycle is a single 16-bit word; a multiple cycle is two or more. A single read or write is 300 ns at 10 MHz, RMW is 400 ns. Multiple-access data rates can run from 10 megabytes per second for noninterleaved page mode to 40 megabytes per second for interleaved fast page mode. (To minimize processing overhead the display processor uses multiple access whenever possible.) The graphics processor uses single RMW cycles for pixel updates and multiple RMW cycles for block moves, while the host processor uses only single cycles.

The Programmer's Model

Software configuration controls the 82786 chip. Host software can program the graphics processor and display processor and set the bus-interface-control parameters. Host software accesses the 82786 through a 128-byte block of addresses that can be memory- or I/O-mapped anywhere in the 4-megabyte address space. The 128 bytes are divided into three areas, one each for the graphics processor, the display processor, and the bus interface. Intel has reserved the unused words in this 128-byte space for future use.

The bus interface controls access to system and graphics memory. The eight bus-interface registers contain the most critical information for 82786 operation. These registers set up the access to all 82786 control registers, interrupts, and their status, DRAM refresh and configuration, and the relative priorities that the display, graphics, and host processors will have when accessing graphics memory.

Before the host processor can use the 82786, it must first set up the memory relocation and mapping, configure the graphics memory, and set refresh parameters and graphics-processor priorities. After allowing sufficient time for all DRAMs to refresh, the host creates screens by programming the graphics processor and displays them by programming the display processor.

Within a bit map, the graphics processor will draw lines, circles, polygons, and arcs. BBLTs can manipulate any rectangular block of bits.

Character block transfers (CBLTs) move character matrices into the bit map with four rotations or directions. The four categories of graphics-processor instructions are nondrawing, drawing-control, geometric-drawing, and bit- and character-block moves.

Nondrawing instructions allow graphics-processor-register access and control-instruction execution, and set up macros of instruction sequences. `NOP` performs nothing, `LINK` directs the graphics processor to the next instruction, and `INTR_GEN` generates an 82786 interrupt to the host processor. You can save the graphics-processor registers that are not directly addressable (registers 1 through 22) and restore them for program swapping by `DUMP_REG` and `LOAD_REG`. You can build subroutines of instructions by using the `ENTER_MACRO` and `EXIT_MACRO` instructions.

Each drawing operation is subject to the parameters set by the drawing-control commands. The major controls are definition of the memory location of the bit map and clipping rectangle, and entry to and exit from pick mode. The memory location and size define the boundaries of the bit map to be operated on. The clipping rectangle restricts pixel updates to a rectangular subset of the bit map. Pick mode allows execution of the display-processor instructions without updating the bit map. Instead, a flag is set when an instruction points to a pixel inside the current clipping rectangle. This allows for quick location of an object selected on the screen.

Other commands control the foreground and background colors, line texture, color-bit mask, and raster operations.

Raster Operations

The color and texture controls let you draw dotted or dashed lines as opaque or transparent. The bit mask can restrict drawing to a subset of color bits, letting you overlay different planes of information on the same screen.

Raster operation defines the logical combination of bits during BBLT and CBLT operations. Control commands also define the character set, the character orientation, and the intercharacter spacing. Both relative and absolute move commands are provided for positioning in the bit map.

Geometric commands are the simplest to describe. The instructions draw points, incremental points, lines, circles, arcs, rectangles, polylines (open multisegment lines), and polygons (closed multisegment lines).

A scan-line instruction is for fast-fill operations once the host processor determines the boundaries. Block-transfer instructions can transfer within a single bit map for simple moves or logical overlays. BBLTs can also transfer across different bit maps to combine separately drawn images.

Character transfers move character matrices into the bit map with any of four orientations or directions. Operating within these design parameters, the display processor can switch windows or displays as fast as once every frame, typically 30 to 60 times per second, with minimal overhead. Instead of rapidly executing simple instructions, the display processor can execute complex instructions at a slower rate. This approach is well-matched to the nature of the display process.

Future Impact

The Intel 82786 will clearly improve the performance of windowing systems, especially systems with slower processors and those performing multitasking. Microsoft's Windows and Digital Research's GEM are two obvious beneficiaries of the graphics coprocessor. But so is every user who loads up a system only to find that more speed, higher resolution, and more windows are needed. In addition to operating systems, applications such as CAD and desktop publishing will benefit significantly from higher performance graphics.

One of the side effects of unloading the host processor and speeding up the display will be to extend the usable lifetime of current systems, especially the 8088-based systems. Manufacturers of new systems might view this with some concern, but they can rest assured that users and software developers will manage to dispose of the extra capacity easily. In fact, experience with high-performance systems typically builds demand for even higher performance. The 82786 is another step in this continuing process. ■


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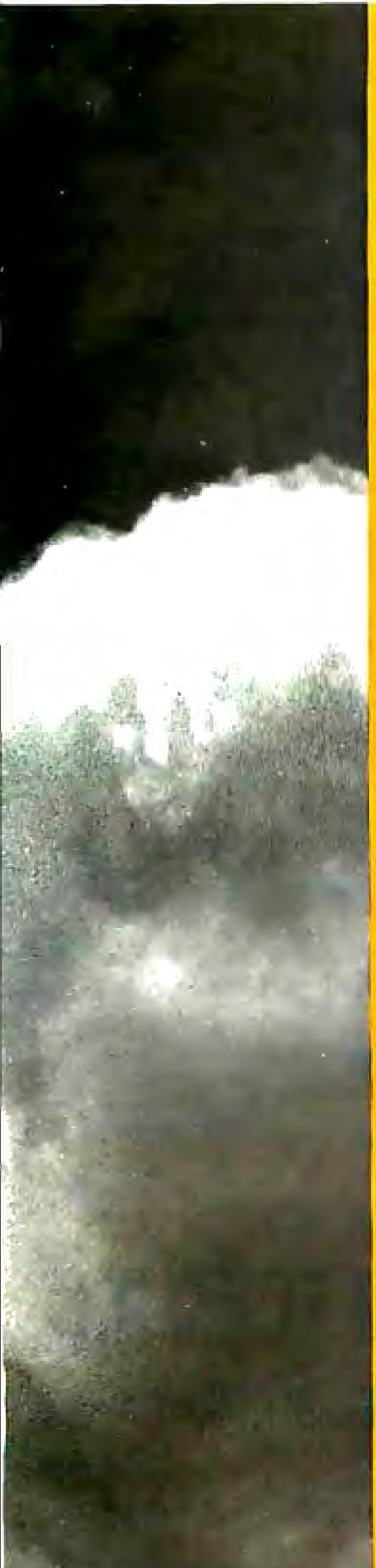

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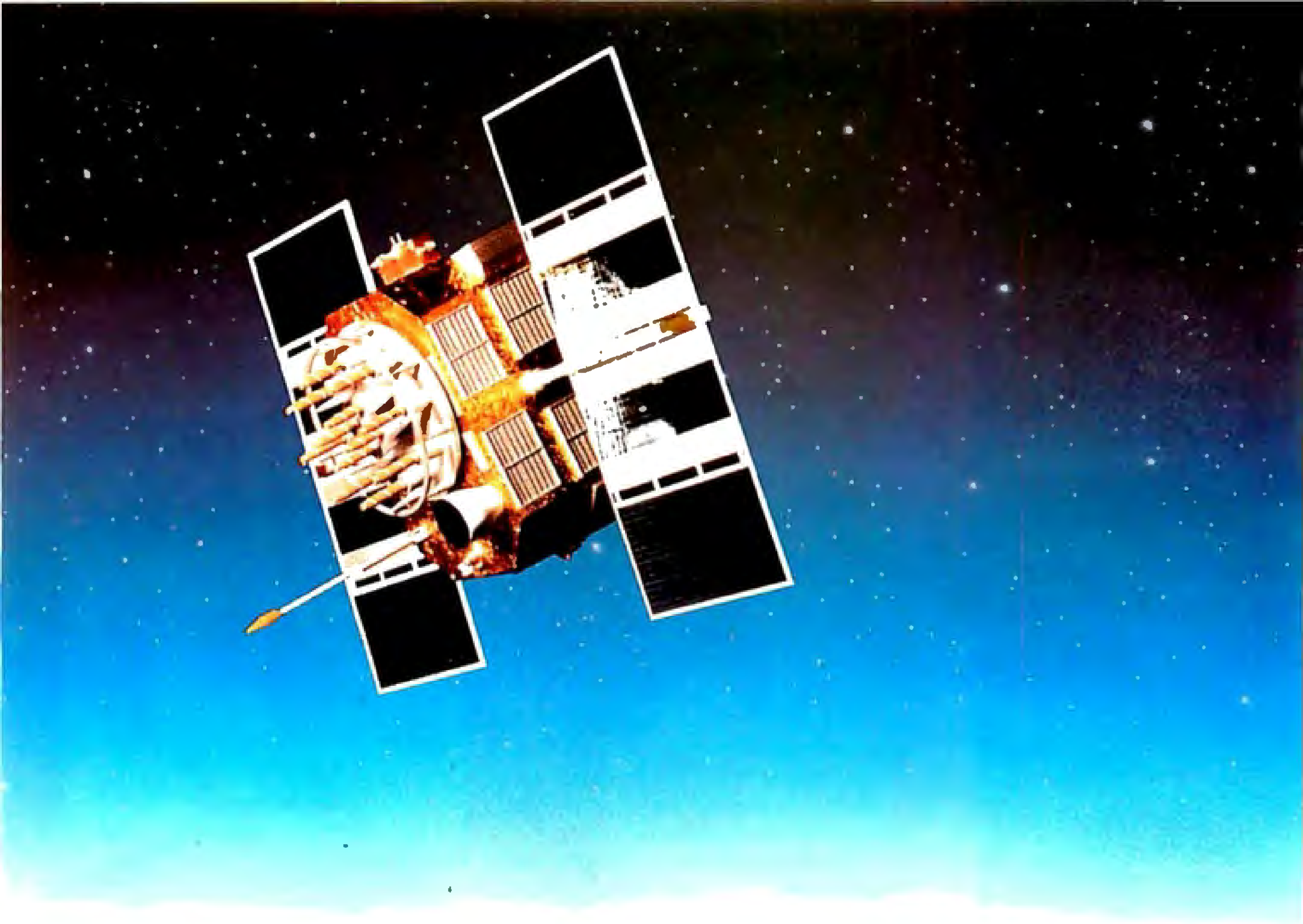

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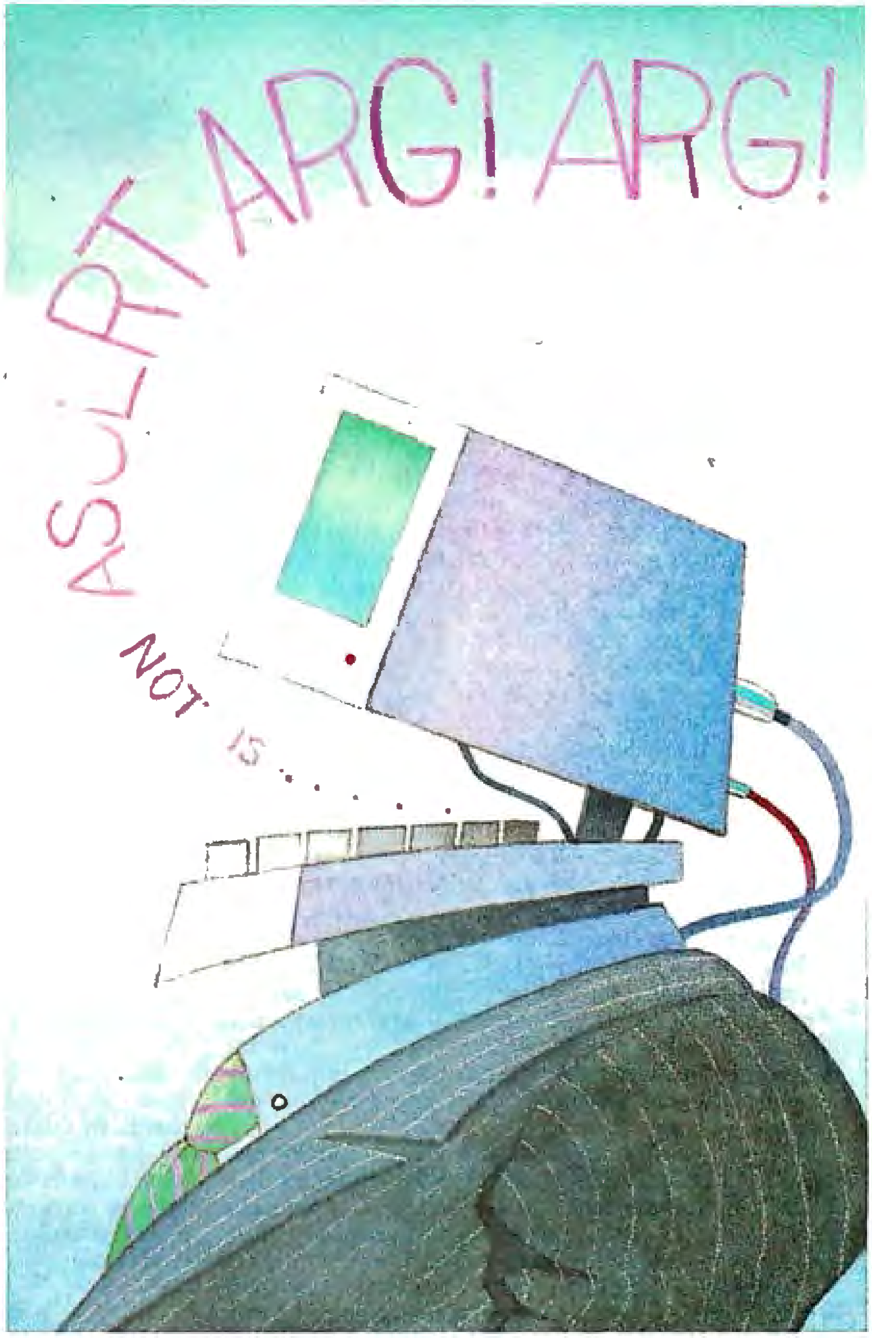
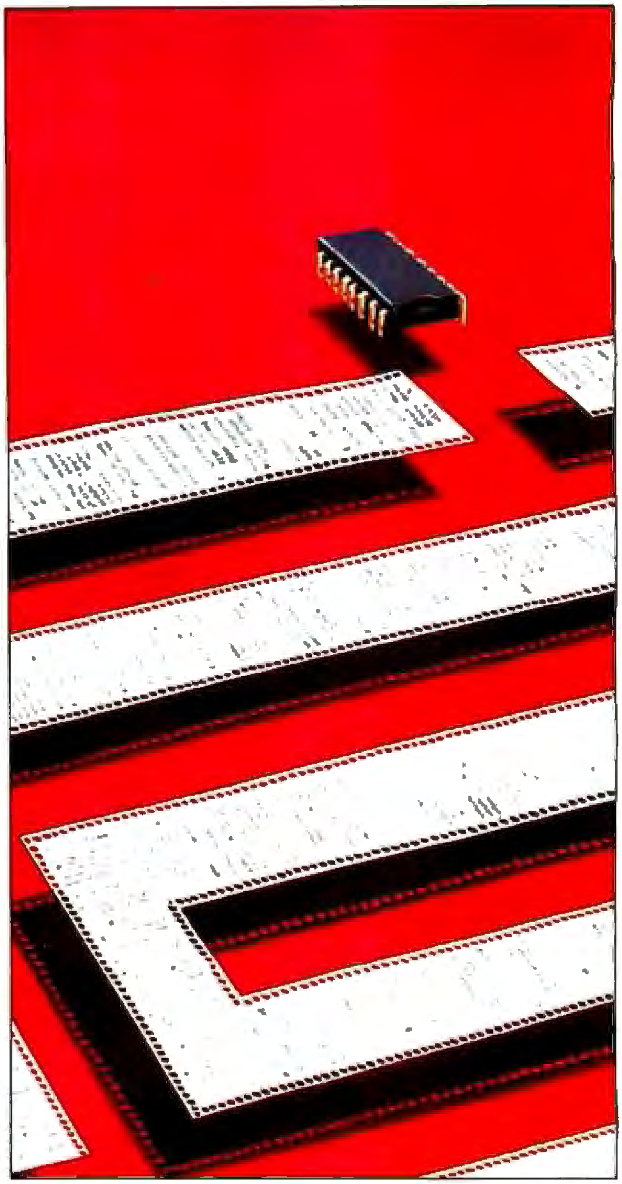


Introduction

Prolog



Two years ago, in August 1985, BYTE focused on a group of programming languages called Declarative Languages. One of these languages, Prolog, has since become so prominent that it now deserves an issue by itself. Prolog has proven to be well-suited to the development of expert systems, natural-language interfaces, databases, and rapid prototyping of applications. Indeed, because of the success of systems such as Borland's Turbo Prolog, the language is becoming one of the more popular programming languages.

We begin our coverage with an introduction to Prolog by William Clocksin, who, with Christopher Mellish, wrote *Programming in Prolog*, generally considered the de facto standard of the language. If you've wondered what Prolog is all about but haven't tried it out, the numerous examples in this tutorial article are the place to start. Mr. Clocksin also includes a description of a current project: applying Prolog to digital circuit analysis.

Although the traditional applications for Prolog have been in the areas of expert systems and natural-language interfaces, the language is amenable to several other applications. Alex Lane describes a novel application: simulating an 8085 microprocessor. Mr. Lane's program, by the way, started off as a way to develop software for his Tandy Model 102 portable computer. He also describes how you could use Prolog to simulate other microprocessors.

Prolog is ideal for solving logical problems, but not for problems involving, for example, arithmetic. Our next author, Catherine Lassez, describes a general framework of languages called the Constraint Logic Programming Scheme. From this framework, a new type of logic programming language has been derived with some powerful capabilities.

Although the so-called Edinburgh dialect of Prolog outlined by Clocksin and Mellish has become more or less standard, many programmers now use Prolog II, which has a slightly different syntax. Prolog II was developed by Alain Colmerauer, whom many regard as the father of Prolog. In "Opening the Prolog III Universe," he describes the latest version of Prolog. Like constraint logic programming, Prolog III has some interesting and powerful capabilities.

And finally, Stan Szpakowicz describes "Logic Grammars," an important part of Prolog that is ideal for language processing but is unfortunately excluded from some commercial Prolog systems. Mr. Szpakowicz, a coauthor of the book *Prolog for Programmers*, shows how a simple compiler can be quickly and concisely written using logic grammars.

On BIX, we have an interesting application article: a logical spreadsheet written in Prolog. The article and its accompanying program were written by Greg Closter and Paul Weiss of Arity Corporation.

In the past two years, a number of powerful Prolog interpreters and compilers have become available for microcomputers. We can expect to see several innovative commercial applications written on these systems in the near future. Many more Prolog applications will undoubtedly be developed for private use. We eagerly await the innovative programs that will be made available by the increasing popularity of Prolog.

—Rich Malloy and Ken Sheldon,
Technical Editors

Illustration by Robert Tinney

A Prolog Primer

An introduction and tutorial to the popular artificial intelligence language

William Clocksin

In the late 1970s, I was responsible for teaching AI languages to graduate students at the Department of Artificial Intelligence, University of Edinburgh. I began planning and writing what I believe was the first textbook on Prolog for the course, and I enlisted the aid of Chris Mellish when it became clear I couldn't handle the whole thing. When *Programming in Prolog* was finished, we thought that perhaps as many as 50 people around the world might be interested in the book, and we were greatly relieved that the well-known science publisher, Springer-Verlag, agreed to publish it. The interest in Prolog and our book after 1982 took us by complete surprise and continues to astonish us.

One reason for the recent popularity of Prolog is that good implementations are available for personal computers. Prolog has gained acceptance as a powerful vehicle for nonnumeric programming, particularly in the AI field. Prolog is also used in many parts of industry, partly for experimental pilot projects, and partly for purposes having considerable commercial value. [Editor's note: *See the text box "Defining Digital Circuits with Prolog."*] Prolog has been recognized by Japan's Fifth-Generation Computer Research Project as the foundation of a new generation of computers that use logical deduction, instead of arithmetic calculation, as their principle of operation: A computation is seen as a deductive proof generated from a set of axioms.

Prolog is the first practical and efficient language to have been inspired by research on logic programming, which is the idea that programs can be built by writing down statements about a problem in a formal logic (usually predicate calculus). From this basis, two issues arise immediately.

First, how should our assumptions and thinking about a problem be set down in statements of logic? Many of our assumptions about a problem are implicit and are difficult to make tangible in a logical way.

Second, how can the statements be interpreted in a mechanical and efficient way to produce the solution to a problem? Logic has no control structures, so an additional interpretation must be put on logical statements.

There will probably never be an ideal logic programming language. Prolog is a start in the right direction, but some theoretical ideals and aesthetic niceties have been compromised to produce a practical and efficient system for real programming.

The Prolog Approach

Prolog is best suited to applications that require symbolic computation. This approach contrasts with more conventional views of computation in the following way: First, the basic data structures used during symbolic computation are not restricted to numbers and strings but can be arbitrary structures of symbols and the relationships among them, possibly containing structures to be interpreted as programs. Second, the basic operations are not restricted to comparison and assignment but include processes of matching and constructing symbol structures. Thus, the Prolog approach to programming is not restricted to numerical calculation but also permits *inference*. Inference allows conclusions to be drawn from a given number of assumptions about the problem.

Many newcomers to Prolog find that the task of writing a Prolog program is not like specifying an algorithm, as in a conventional programming language. Instead, the Prolog programmer asks what formal relationships and objects occur in the problem and what relationships are true about the desired solution. The Prolog approach is to describe known facts and relationships about a problem rather than to prescribe a sequence of steps taken by a computer to solve the problem. When you program your computer in Prolog, the computer carries out the computation partly according to whatever new facts Prolog can "infer" from the given ones, and only partly according to explicit control information that you supply.

Novice programmers find that well-written Prolog programs are more comprehensible than equivalent programs written in conventional languages, but they tend not to appreciate the limitations

continued

William Clocksin (University of Cambridge, Corn Exchange St., Cambridge CB2 3QG, England) is an assistant director of research at Cambridge's Computer Laboratory. His research concentrates on inference machines and the application of logic programming to control systems and design automation.

Defining Digital Circuits with Prolog

William Clocksin

Any digital logic circuit can be built from standard logic gates such as NAND and INVert. The behavior of a logic gate is readily described as Prolog clauses, and logic circuits can be defined and simulated by Prolog programs. For example, an inverter is defined by the two clauses:

```
inv(0,1).
inv(1,0).
```

The constants 0 and 1 stand for logic low and logic high signals, respectively. A goal of the form `inv(X,Y)` will take the input signal X and invert it, giving the output signal Y. Similarly, the NAND gate is represented as the goal `nand(X,Y,Z)`, which takes inputs X and Y and gives output Z. Recall that NAND is the inverse of AND, for which the output is 1 only if all the inputs are 1. The truth table for AND and NAND is

X			
U	0	0	1
0	1	0	1
1		0	1
1			0

Prolog rules. The head of the rule gives the name of the circuit together with its inputs and outputs; the body of the rule contains one goal for each component of the circuit. Wires connect the ports (inputs or outputs) of components. Wires are represented as variables, so arguments having the same variable name indicates that a wire connects the corresponding ports. Here is an example, where a circuit is defined to perform the exclusive-OR (XOR) function, where the output is 1 when the inputs are different and 0 when the inputs are the same. The XOR truth table is

X	Y	XOR
0	0	0
0	1	1
1	0	1
1	1	0

The circuitry to perform the XOR is shown in figure A and is defined by the following Prolog rule:

```
xor(X,Y,Z) :-
```

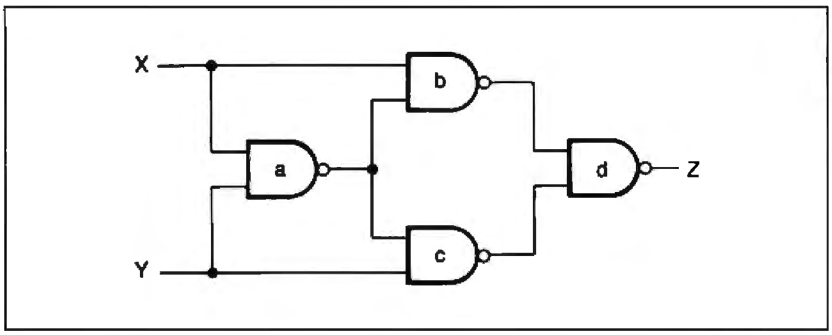


Figure A: *A circuit designed to perform the XOR function, using NAND gates. This circuit can be simulated by a short Prolog program.*

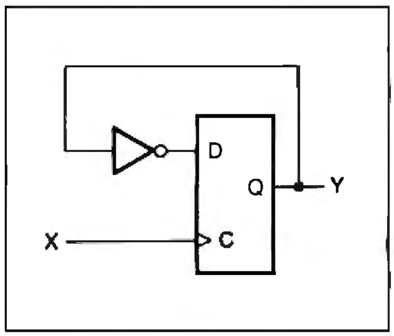


Figure B: *A divide-by-2 frequency divider circuit, which can be easily simulated in Prolog.*

that conventional languages place on their use of computing resources.

On the other hand, programmers experienced in conventional languages are better prepared to deal with abstract concepts such as variables and control flow, but they may find Prolog difficult to adapt to and may need a lot of convincing before they consider Prolog a useful programming tool.

You can view programming in Prolog as

- Specifying some *facts* and *rules* about objects and their relationships.
- Asking *questions* about objects and their relationships.

The program that is presented to a Prolog system consists of a database that contains the facts and rules that are relevant to a problem.

The problem is then solved by formulating it as a question to be answered by the system using the information contained in the database. For this reason, Prolog is a conversational system: You enter facts, rules, and questions at the keyboard, and the system prints answers on its display.

First, the Facts

When you say "John owns the book," you are declaring that a relationship (ownership) exists between one individual object John and another individual object denoted by "the book." This relationship has a particular order: John owns the book, but the book does not own John.

When you ask the question "Does John own the book?," you are attempting to find out about a relationship. One way of writing the fact "John owns the book" in Prolog is

```
owns(john, book).
```

I am using the standard "Edinburgh" notation for Prolog, which is probably the most common. In this notation, the names of all relationships and objects begin with a lowercase letter. The relationship is written first, and the objects involved are written separated by commas and enclosed in parentheses. A period is placed at the end of the fact.

```
nand(X,Y,A),
nand(X,A,B),
nand(Y,A,C),
nand(B,C,Z).
```

The local variables A, B, and C are names for the internal connections of the circuit. These connections are effectively "hidden" from any program that uses the xor predicate as one of its goals. Circuits can be constructed of arbitrary "depth," so, for example, xor goals can be used to define parity testing circuits, which can be used in interface circuits, which can be used in larger circuits, and so on.

Simulating a circuit is as easy as running a Prolog program. Here are some things you can do with the XOR circuit just defined (the computer's reply follows each query):

```
?- xor(0,1,X).
X=1

?-xor(X,0,Y).
X=0, Y=0;
X=1, Y=1

?- xor(X,Y,1).
X=0, Y=1;
X=1, Y=0
```

You can verify these results by checking them against the XOR truth table. Notice that you can do much more than simply feeding in inputs to obtain outputs. Because of the bidirectional nature of pattern matching, you can also find any conditions under which combinations of inputs and outputs have certain signal values. For example, the last question asked for the possible inputs that must occur for the output of an XOR gate to be 1. There are two possibilities, as shown. This method of testing "hypothetical states" is a useful technique and can be applied to arbitrarily large circuits in Prolog.

We are not restricted to simple combinational circuits. We can use lists and recursion in defining clocked sequential circuits. Here is a very simple divide-by-2 frequency divider circuit, composed of a D-type flip-flop and an inverter, such that a pulse train arriving at X will appear at Y halved in frequency, as shown in figure B.

First you should specify the behavior of a D-type flip-flop. The basic form of each fact is dff(D,C,Q,Qn), for Data input D, Clock input C, current state Q, and next state Qn. Eight facts are required:

```
dff(1,0,1,1)
dff(1,0,0,0)
dff(0,0,1,1)
dff(0,0,0,0)
dff(1,1,1,1)
dff(1,1,0,1)
dff(0,1,1,0)
dff(0,1,0,0)
```

It is assumed that the flip-flop is triggered on the rising edge of the clock pulse. The first four facts define the flip-flop's response to a falling clock pulse (C=0), and the last four facts define the response on a rising clock pulse (C=1).

The next step is to write a rule defining the divider circuit.

```
div(X,Q,Y) :- inv(Q,D),
  dff(D,X,Q,Y).
```

It is important to include an extra argument Q to represent the current state of the circuit. Later you'll see how to "jam" this argument with an initial value when the simulation begins.

The definition of inv was given earlier. The input and output of the divider circuit are given by a train of pulses, represented by Prolog lists. A typical input to the circuit might be [1,1,0,1,0,1]; each 1 in this list denotes a pulse (rising edge), and each 0 denotes the absence of a pulse. We can now embed the div circuit into a "test circuit" by writing a Prolog procedure that recurs over an input list of pulses. The current state is jammed with an initial value (0), and the output states are collected into an output list. The goal divide(P,I,Q), when given a pulse list P and initial state I, will thus construct the output pulse list Q. The definition of this test circuit is

```
divide([],S,[]).
divide([P|Ps],S,[Q|Qs]) :-
  div(P,S,Q), divide(Ps,Q,Qs).
```

Sample simulations of this circuit (with the computer's reply) follow:

```
?- divide([1,1,1,1,1,1],0,Q).
Q=[1,0,1,0,1,0]

?- divide([0,1,0,0,1,1,0,0],
    0,Q).
Q=[0,1,1,1,0,1,1,1]
```

I have only touched on some very elementary aspects of simulating digital circuits. For further information on how Prolog can be used for several tasks in digital circuit and VLSI circuit analysis, refer to my paper "Logic Programming and Digital Circuit Analysis," in the *Journal of Logic Programming* 4, no. 1 (March 1987), pages 59-82.

It is necessary that the objects listed appear in a consistent order. The particular order is not important as long as it is consistent. In the example above, I have written the owner first and the object owned second.

If you define a "likes" relationship between a liker and a liked person, you might write

```
likes(john, mary).
```

to represent the fact that John likes Mary. This is not the same fact as

```
likes(mary, john).
```

If you wish to represent the fact that John likes Mary, and also that Mary likes John, you must say so in two separate facts.

The name of a relationship is called a *predicate*, and the objects inside the parentheses are called *arguments*. So the above example is a fact about the predicate likes, which has two arguments, john and mary.

On to Questions

Once you have collected some facts in a database, you can then ask questions about them. Here is a database of some friends:

```
likes(john, mary).
likes(john, fred).
likes(mary, fred).
likes(fred, john).
```

In Prolog, you ask "Does John like Mary?" by typing the following *goal*:

```
?- likes(john, mary).
```

Questions are entered at the Prolog "?-" prompt, as shown.

To answer this question, the Prolog system examines each of the entries in the database, looking for facts that match the question. In this case there is a matching fact (the first one), so the Prolog system answers

```
yes.
```

Given the above database, if you ask the question

continued

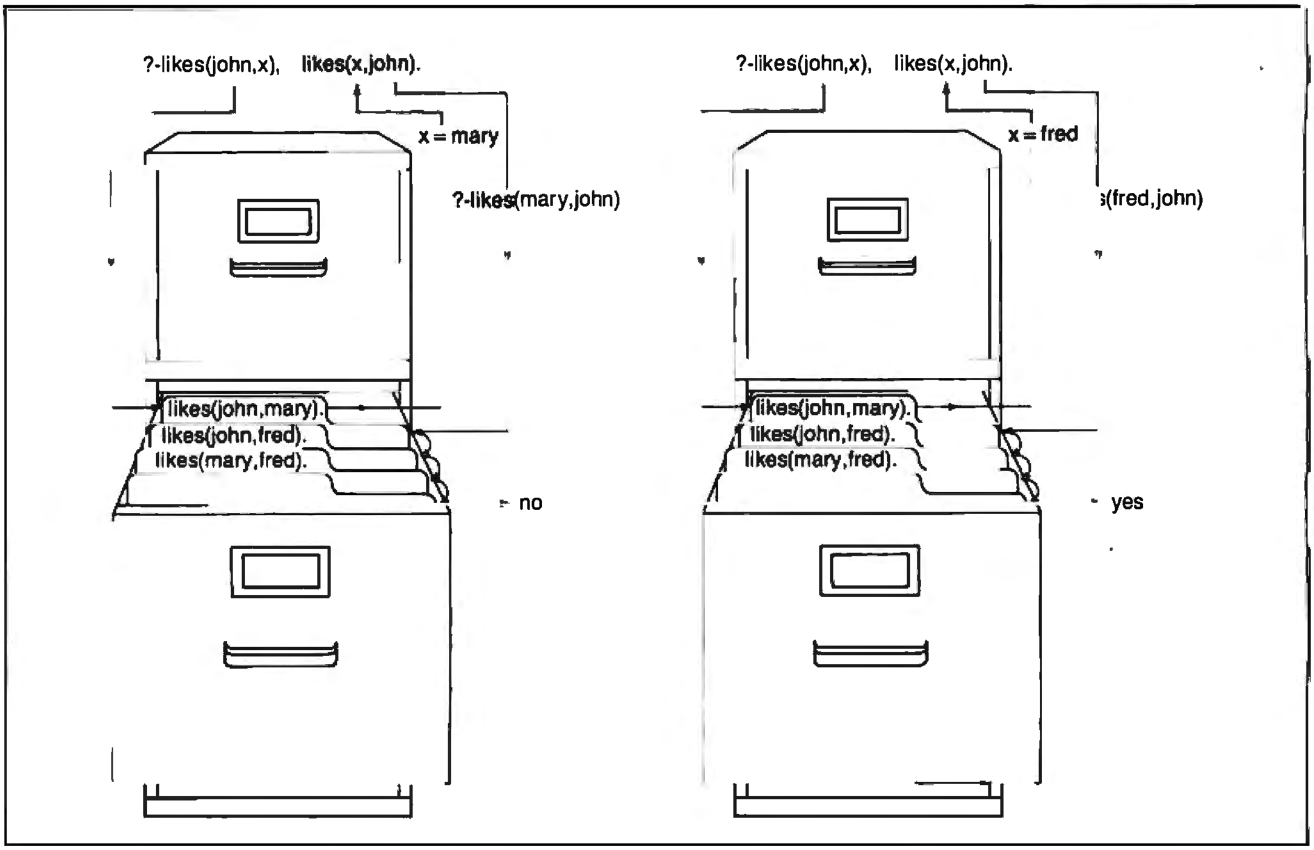


Figure 1: *With Prolog, you can set up a database of facts about who likes whom and use two goals plus the variable X to ask whether John likes anyone who likes John.*

```
?-likes(mary, john).
```

then the Prolog system will answer

```
no.
```

This response actually means that the fact cannot be proved by what is in the database.

Questions can also include *variables.* In Prolog, a variable takes the place of an object the programmer is unable or unwilling to name at the time of writing the program. A variable stands for an object; its usage is closer to high school algebra than to conventional computer languages. In particular, variables cannot be assigned to, but you can instead substitute objects for variables. Also, objects can contain variables, as you'll see later.

Using a variable, you can ask "Is there some thing *X* that John likes?" by typing

```
?- likes(john, X).
```

In our notation, any word that begins with an uppercase letter is a variable. In the above database, two facts happen to match this question. The first is mary, so the system prints out

```
X = mary
```

and waits for a reply from you. In Edinburgh-standard Prolog implementations, if you press the Return key, the system will abandon the search for more matching facts. If you type a semicolon, then the search will be continued. A complete interaction might look like this:

```
?- likes(john, X).
X = mary ;
X = john ;
no
```

The last reply, no, means there are no more facts that can satisfy the question.

Another way to ask more complicated questions is to use *conjunctions.* If you wish to know whether John and Mary like each other, you can state the question in the form of two goals, each separated by a comma. The comma is pronounced "and":

```
?- likes(john,mary),
      likes(mary,john).
no
```

Using variables, you can use two goals to ask whether John likes anyone who likes John:

```
?- likes(john,X), likes(X,john).
X = fred
```

In the first goal of this question, X is initially unknown. However, when searching the database, the Prolog system finds a fact that matches if X is mary (see figure 1). As a result of this find, the system replaces any occurrence of X in the question with mary.

Next, Prolog considers the second goal. With the variable substituted, the goal now reads as likes(mary,john). This goal fails because there is nothing to match it in the database. However, the system had not searched the database completely before finding a match for the first goal; there might be some other fact that matches the first goal.

Indeed there is, when X is fred. So now the system substitutes fred for X and tries the second goal again: likes(fred, john). This time the goal succeeds because the system finds a matching fact in the database. Both goals thus succeed, and Prolog prints out the first (and in this case the only) answer as shown above.

It is important to note that the system alternates between two neighboring goals in a conjunction to find an answer that satisfies them both. An arbitrary number of goals separated by commas can partici-

continued

A variable's usage is closer to high school algebra than to conventional languages.

pate in this way. This is the basis of a powerful technique called *backtracking*, by which all conjunctions of goals are solved.

Finally, Rules

Often it is useful to express many facts in the form of a single *rule*. Suppose I want to express the fact that John likes everyone who drives a Ford car. It is far simpler to store a rule about what John likes, instead of listing all the people he likes. You can represent this as "John likes *X* provided that *X* drives a Ford." You write this as the following rule:

```
likes(john,X) :- drives(X,ford).
```

The rule is composed of a head, which describes the result of the rule, and a body, which puts conditions on whether the head is true. The head and body are separated by the ":-" sign, which means "provided that" or simply "if." Again, a period is written at the end of a rule. For this example, you need to have a database of facts of the form drives(X,Y), meaning that person *X* drives car *Y*.

Rules can be entered in the database the same way as facts. When programming, you usually put in a mixture of facts and rules, depending how you decide to represent the problem. If, when searching the database, the system finds the head of a rule that matches the current goal, it will try to satisfy the subgoals in the body of that rule, using the same "match and backtrack" style, in order to satisfy the original goal.

Let's look at a simple rule about sisters. Suppose you have two people *X* and *Y*. Person *X* is a sister of person *Y* provided that *X* is female and that *X* and *Y* have the same parents. This definition translates directly into a Prolog rule as

```
sister(X,Y) :-
     female(X),
     parents(X,Ma,Pa),
     parents(Y,Ma,Pa).
```

Notice that Prolog is not fussy about how you write program text on the page. This rule is read, "It is a fact that *X* is a sister of *Y* provided that *X* is female, and the parents of *X* are some objects Ma and Pa, and the parents of *Y* are (the same) objects Ma and Pa." Here are some facts about a family that will help this rule to succeed:

```
female(alice).
female(victoria).
male(albert).
male(edward).
parents(edward,victoria,albert).
parents(alice,victoria,albert).
```

Now you may ask whether Alice is a sister of Edward:

```
?- sister(alice, edward).
yes
```

Let's try a few more questions, each shown with the answer the system gives. Notice the use of variables in some questions:

```
?- sister(alice,victoria).
no

?- sister(alice,alice).
yes

?- sister(alice,X).
X = edward

?- sister(X,Y).
X = alice, Y = edward ;
X = alice, Y = alice ;
no

?- sister(X,X)
X = alice

?- sister(X,Y), parents(Z,W,Y).
no
```

The last question asks if *X* is the sister of someone (*Y*) who is the father of a child (*Z*). The system finds nothing in the database that satisfies such a question.

Here is a collection of simple one-rule examples. Each rule uses backtracking to find a set of objects that satisfies the goals in the body. Remember that these rules are not questions but compact ways of expressing a complex relationship among objects.

Example 1: "John likes anyone who likes wine and food."

```
likes(john,X) :-
     likes(X,wine),
     likes(X,food).
```

Example 2: "*X* was on the throne during year *Y* if: *X* reigned between years *A* and *B*, and year *Y* falls between years *A* and *B*." In this example, you assume that clauses for reigned exist in the database. In the following rule, the built-in infix operator "=<" has the usual meaning of "less than or equal to":

```
on_throne(X,Y) :-
     reigned(X,A,B),
     A =< Y,
     Y =< B.
```

Relevant facts for the database pertaining to the fifteenth-century House of Avis (Portugal) are:

```
reigned(duarte,1433,1438).
reigned(alfonso_V,1438,1481).
reigned(john_II,1481,1495).
```

Example 3: "The population density of country *X* is *Y*." Here you assume that the database contains facts relating a country to its population and area. In the following rule, you use the built-in infix is operator, which evaluates the arithmetic expression on its right-hand side and matches it with the object on its left-hand side:

```
density(X,Y) :-
     population(X,P),
     area (X,A),
     Y is P / A.
```

Relevant facts for population (in millions of people) and area (in millions of square miles) for 1976 look like this:

```
population(usa,203).
area(usa,3).
population(india,548).
area(india,1).
population(brazil,108).
area(brazil,3).
```

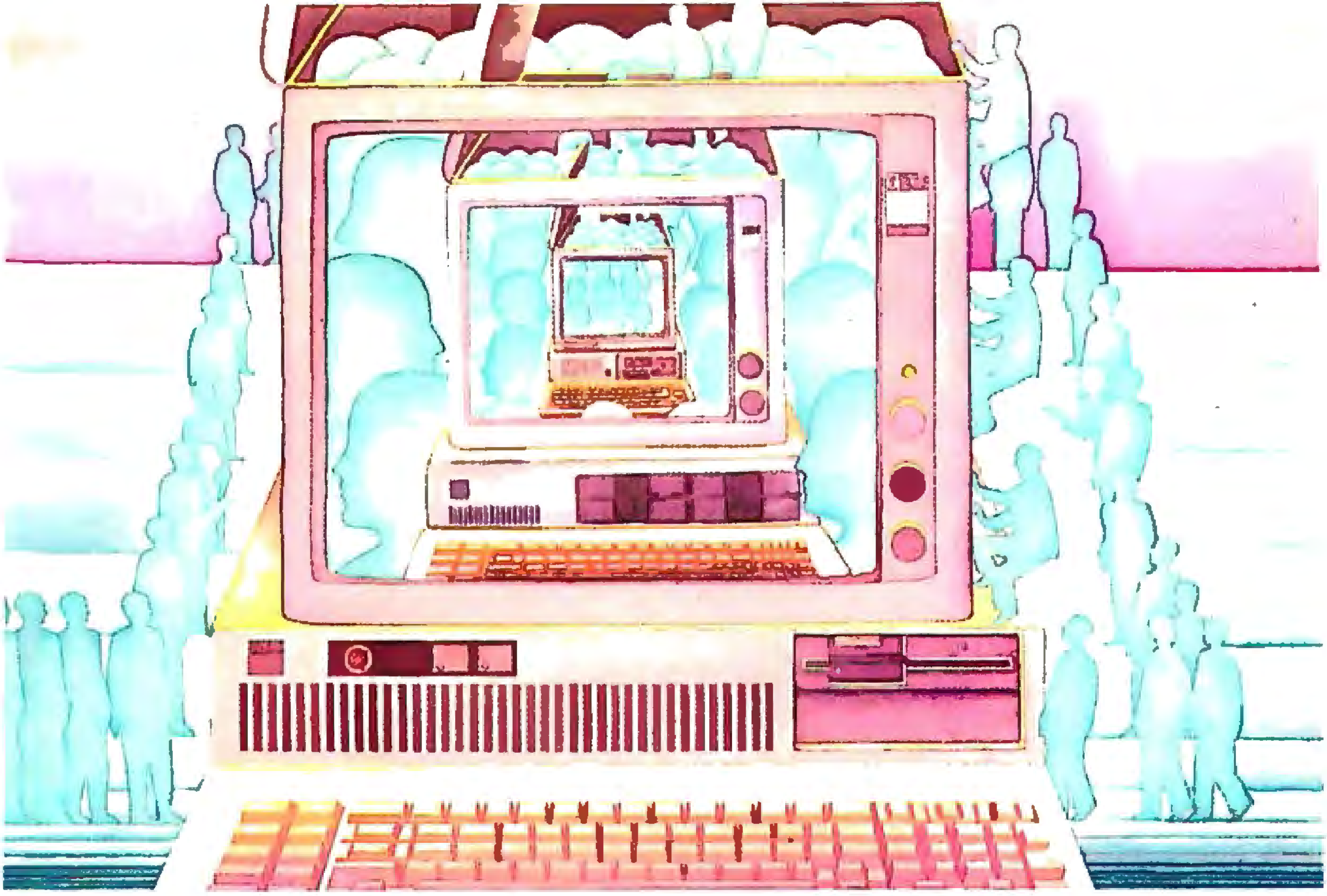
Using Data Structures

A structure is an individual object that is named by listing its component parts. For example, you can treat the kings of the previous example in a more flexible way. Each king is an individual consisting of a name, a serial number, and the country ruled. So you can represent "Alfonso the V of Portugal" as king(alfonso, 5,portugal) and "Henry the VIII of England" as the object king(henry, 8,england).

Structures are written with a *type* of individual (like king) and components that identify the details of the individual. A structure looks like a fact, but structures are written only when an *object* is expected—that is, "inside" facts and rules. Here is another way to write a program using structures to represent details of the individual kings:

```
reigned(king(duarte,0,portugal),
  1433,1438).
reigned(king(john,2,portugal),
  1481,1495).
reigned(king(john,3,sweden),
```

continued



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```
  1568,1592).
on_throne(Country,King,
  Serial,Year) :-
   reigned(king(King,Serial,
   Country),A,B),
   A =< Y,
   Y =< B.
```

Remember that any word beginning with a capital letter is a variable. Now, to ask which John ruled an unknown country in 1588 (the year of the Spanish Armada), you would ask:

```
?- on_throne(C,john,S,1588).
C = sweden
S = 3
```

Here is another example, where you use structures to represent parts that you might order from a supplier. You can make a simplified description of a car using the structure

```
car(Make,Color,Year)
```

so that a list of cars for sale (with seller and price) can be written like this:

```
sale(car(ford,white,1955),
  smith,100).
sale(car(volvo,blue,1980),
  jones,2000).
sale(car(fiat,green,1974),
  jones,1000).
```

You can now ask the following questions. First, can any seller (*S*) supply any car (*C*) costing less than a price (*P*) $500?

```
?- sale(C,S,P), P < 500.
```

In this question, the built-in operator "<" has the usual meaning of "less than." Using the above database, the answer would be printed

```
C = car(ford,white,1955),
S = smith,
P = 100.
```

Next, can Smith supply the same car as Jones at a lower price?

```
?- sale(C,smith,SmithPrice),
  sale(C,jones,JonesPrice),
  SmithPrice < JonesPrice.
```

The answer here would be no. Although Smith can supply *some* car cheaper than Jones, he cannot supply the *same* kind of car Jones could supply. Finally, you want to know if anyone can supply a green car:

```
?- sale(car(M,green,Y),S,P).
M = fiat,
Y = 1974,
S = jones,
P = 1000
```

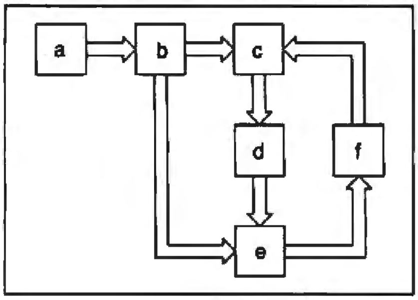

Figure 2: *The use of Prolog's list feature lets you design a program to plan routes through the rooms in a maze, without endlessly visiting the same rooms (see text). Arrows indicate a one-way path.*

Although the car example here uses the sale facts only to answer direct questions from the user, there is nothing to stop you from using sale within programs.

List Processing

Just as in the language LISP, the data structure known as the *list* plays an important part in Prolog programs. Lists are just ordinary structures, but they are so common that Prolog has special "syntactic sugar" to make lists easier to write. The elements in a list are separated by commas, and the whole list is enclosed in a pair of brackets. Lists can contain any objects, even variables and structures (and other lists). The empty list contains no objects. Here are some examples:

```
[john,will,join,the,company]
[this,[has,several(types,of)],
  elements]
[]
```

The head of a list is its first element, and the tail of a list is the list without its first element. If a list can be described only by its head and tail, then you use the notation [X|Y] where X is the head and Y is the tail. This is useful in pattern matching. For example, you can define a predicate, member, which succeeds if its first argument is a member of the list given in its second argument. For example, you can find out if Darwin is in a list of influential nineteenth-century thinkers:

```
?- member(darwin,[marx,
  darwin,freud]).
yes
```

To define member, you need two statements. The first is, "It is a fact that *X* is a member of a list if *X* is the head of the list." The second is, "*X* is a member of a list provided that *X* is a member of the tail of the list." Writing this in Prolog gives

```
member(X,[X|Y]).
member(X,[H|L]) :- member(X,L).
```

This is a recursive definition that is executed in the same way as any other kind of Prolog statement. A bonus of using variables is using member to search a list:

```
?- member(X,[marx,darwin,freud]).
X = marx ;
X = darwin ;
X = freud
```

In the next example, you use Prolog to plan routes through a maze (see figure 2). Rooms in the maze are identified by letters, and path facts indicate how the rooms are connected. In the following example database, path(X,Y) means that there is a one-way path connecting room *X* to room *Y*:

```
path(a,b).
path(b,c).
path(c,d).
path(f,c).
path(b,e).
path(d,e).
path(e,f).
```

Here is a definition of route(X,Y), which succeeds if there is a route from room *X* to room *Y*. You need two statements. The first is, "It is a fact that there is a route from *X* to *X*." The second is, "There is a route from *X* to *Y* provided that there is a path from room *X* to some other room *Z*, and you can plan a route from *Z* to *Y*."

```
route(X,X).
route(X,Y) :- path(X,Z),
  route(Z,Y).
```

This program does not allow for the possibility that the maze may have loops. As a result, the program itself might get into an endless loop by re-searching rooms it has searched before. To avoid this possibility, the program should keep a list of room names that have been visited and ensure it visits only rooms not on the list. In this new version, the third argument T is a "trail" of room numbers, represented by a list:

```
route(X,X,T).
route(X,Y,T) :-
     path(X,Z),
     not(member(Z,T)),
     route(Z,Y,[Z|T]).
```

This time, *Z* is on the route provided it is

continued

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not a member of the trail list. The final goal inserts Z onto the list by making a list that has Z as its head and the "list so far" as its tail. The whole thing is passed to the recursive call of route. Normally, you would begin to search a maze with a question that initialized the trail as the empty list (i.e., started off with no rooms marked as visited).

```
?- route(a,d,[ ]).
yes
```

Initializing the list to contain some room numbers would permit the program to search the maze, avoiding those rooms. This simple program can be extended to perform an interesting variety of searching tasks.

Some Prolog Myths

Promotion of Prolog in recent years has built up high expectations in potential users. Some Prolog zealots have gone so far as to say that you cannot write a faulty program in Prolog: If you're writing in logic, then every program you write always turns out to be logically correct.

This is, of course, not the case. You can just as easily make mistakes in Prolog as in any other form of programming. A more subtle (and regrettably more seductive) myth is that the logical reasoning of the programmer can be translated directly into a Prolog program that correctly executes the programmer's intention. Those who believe this myth sooner or later fall into various logical traps and then blame Prolog because their program does not behave as expected. In fact, some promoters are attributing to Prolog powers that it simply does not have. Falling into traps is usually the result of programmers' misplaced confidence in their abilities to reason about problems. You should remember the following three points:

- Don't assume that the programmer's reasoning is always logical.
- Don't assume that human-oriented reasoning, whether logical or not, can be directly translated into a program.
- Don't assume that the purpose of Prolog is to execute directly translated human-oriented reasoning.

Many people, even programmers, do not have enough experience in thinking logically and carefully enough to expect that their every requirement can be easily and directly translated into a correct Prolog program. This should come as no surprise and has nothing to do with whether Prolog contains more or fewer special features.

As with any language, Prolog has certain idioms that fluent users employ to obtain clear and natural solutions to many problems. Some of the Prolog programs you see in print are not very idiomatic and are bad examples of how to use Prolog.

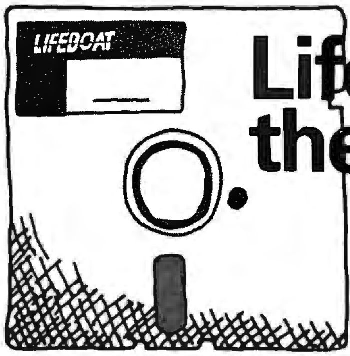
I hope that one day the Prolog equivalent of "structured programming" will make the programmer's task easier. Some people suppose that programming in pure logic will make all these problems vanish. In fact, programming in pure logic does not make the job easier: Such programming is more demanding of human reasoning, as there are even fewer implicit assumptions available to guide design decisions.

Prolog Resources

Here is a list of books that can help you to learn about Prolog and logic programming. Details are given in the references at the end of the article.

As I mentioned at the beginning, I believe the first textbook specifically on Prolog was *Programming in Prolog* by Chris Mellish and myself. Had we known how popular the book was going to be, we

continued



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would have given a broader coverage of the field and would have taken more care over presentation. We have taken the opportunity to revise the book every few years, and the third edition is to appear this year.

Fortunately, much has been learned since 1980 about teaching Prolog, and I can also recommend the following excellent books, which have recently arrived on the market: for beginners, the delightful little book *A Prolog Primer* by Jean Rogers, and for advanced Prolog programmers, *The Art of Prolog* by Leon Sterling and Ehud Shapiro. Sterling and Shapiro's masterful book is a comprehensive collection of programming techniques, examples, exercises, historical notes, and research results.

As for the more theoretical aspects of computational logic, it is hard to beat the first book on the subject, *Logic for Problem Solving* by Robert Kowalski. This book, a collection of essays on many topics relevant to logic and the relationship of logic to computation, is responsible for shaping the field of logic programming as we know it today. The well-written book *Introduction to Logic Programming* by Christopher Hogger covers the middle ground between the programming texts and Kowalski's book. Of particular interest are the discussion of deriving logic programs from specifications and the section on implementing Prolog.

A Final Word

I have not talked about every feature of Prolog. For example, with Prolog, you can easily do pattern matching, which is useful when writing compilers and some AI programs. Prolog also has a Grammar Rules notation, which is useful for building parsers. But I hope this article can give you a start. You should now know enough about Prolog to tinker with programs like the treasure-hunt program given in the August 1985 BYTE, and the programs in the November 1986 BYTE for decision support and playing the game Cluedo. ■

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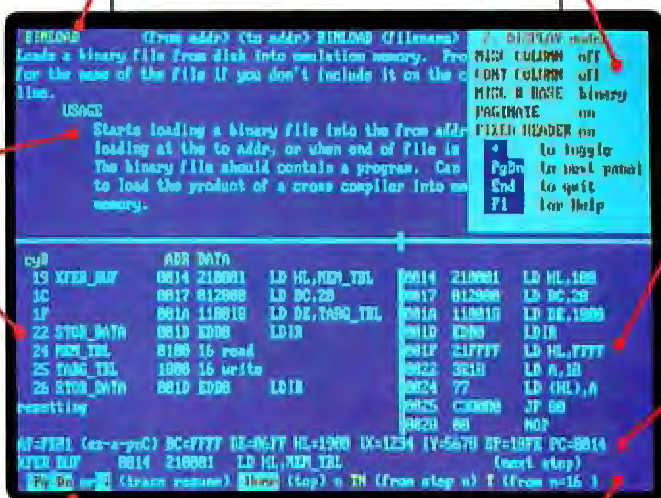

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Simulating a Microprocessor

A Prolog program that simulates an 8-bit 8085 microprocessor

Alex Lane

ONE OF THE most discouraging aspects of learning about microprocessors is keeping track of what goes on inside the device when an instruction executes. I've found that the best way to learn about a particular device, like a 6502 or an 8080, is to step through some code as it executes under the supervision of a debugger program. Sometimes, though, that's not feasible because the device you want to learn about is not the one you own or is not available.

I recalled the whole frustrating process when a neighboring high schooler asked me to help him understand the workings of a fictitious Simple Architecture Microprocessor (SAM), which executes 4-bit instructions in a 12-bit address space (see reference 1). I winced as he brought out a sheaf of paper chronicling his attempts to keep track of the SAM state from instruction to instruction. Surely, I thought, there's got to be a better way.

Later, working on a Prolog database, I recalled having read that Prolog was a good prototyping language, allowing rapid transfer of ideas into running code. Curiosity led me to outline a scheme for representing the SAM, the memory, and the execution of the SAM instructions in Prolog. As I got deeper into the outline, which was written using Prolog's predicate notation, I suddenly realized that I was inadvertently writing a substantial part of a program to simulate the SAM.

The technique for simulating a microprocessor is fairly straightforward: Establish a structure to reflect the processor's architecture, and establish procedures for working with the structure for the various op codes. This technique is used here to develop the simulation of a more powerful (and real) microprocessor, the Intel 8085, a general-purpose 8-bit device that has been around since the late 1970s (see reference 2). Despite its "age," the 8085 is still used; the Tandy Model 102 and NEC 8201 laptops both use a CMOS version of this workhorse.

The simulation was written in Arity/Prolog, mainly because it implements the widely used DEC-10 (Edinburgh) syntax and, theoretically, should port to other Prologs with minimum fuss. Conversion to Borland's Turbo Prolog, however, may require more work than for others.

The program, available separately from BYTE (see page 168), is composed of several files: START80.ARI, MON80.ARI, PARSE80.ARI, TOKENS80.ARI, PREDS80.ARI, OPS8085.ARI, MEMORY.ARI, and HELP.ARI. The ARI filename extension is used by Arity/Prolog. The total amount of code is approximately 45K bytes.

Keeping Track of Business

The first thing I learned when implementing the SAM processor is the need to keep track of the current processor state. In Prolog, there are basically two ways to do this. First, you can pass the state from predicate to predicate:

```
do_this(OldState,NewState),
do_that(NewState,NewerState),
do_the_other(NewerState,
    NewestState).
```

This is roughly akin to passing variable values to functions in C. A better way to do this in C would be to declare global variables and let each function work its will on the variables. Unfortunately, this scheme is not possible in Prolog. The closest you can come to using global variables in Prolog is to `retract` (remove) a clause containing that variable from the program and then `assert` (add) it back again with a new value.

The first approach, passing the state, has the advantage of allowing you to write cleaner-looking predicates. The program is, however, more difficult to debug, as every time you terminate the program (with, for example, Ctrl-C), the system restores everything to the original state. The second approach, though not as elegant, is easier to debug and keep track of. Despite the inelegance of expressing the retraction and assertion, I thought it was more suitable for the job at hand.

Representing Memory

The 8085's read-write "memory" is represented simply using the predicate

```
memory(Address,Data).
```

What is attractive about this Prolog representation is that the contents of an address are fetched by calling this predicate

continued

Alex Lane is a senior software engineer living in Jacksonville, Florida. In his spare time, he is the moderator of BIX's Prolog conference. He can be reached at 1873 Bartram Rd., Jacksonville, FL 32207.

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In Canada, contact McGraw-Hill Ryerson, Ltd. Phone 416-293-1911 with only the address instantiated and letting Prolog search its database for the matching data. For example, the query

```
?- memory(100,X).
```

is answered with

```
X = 3
```

if address 100 contains the value 3. In fact, this predicate could also be used to simulate an associative memory (a type of storage used, for example, in memory cache systems, in which locations are identified by their contents). This could be done by calling the predicate with only the data instantiated.

Changing the contents of our 8085's "memory" is a bit more complicated. First, the old predicate must be retracted, and then a new predicate, with the correct data instantiated, must be asserted. The entire procedure is accomplished by the predicate put_mem, which looks like this:

```
put_mem(Address,NewData) :-
        retract(memory
        (Address,_)).
        asserta(memory
        (Address,NewData)).
```

For this article, I implemented the memory predicate in Prolog, which means a separate predicate was asserted for each address. This is expensive in terms of the actual computer memory needed to store the predicates, and it forced me to limit the "address space" of the simulated microprocessor to a paltry 256 bytes.

A better way to implement memory would be to write memory as a module in some other language (like C or assembly language) and then use the interfacing capability commonly found in most microcomputer Prolog implementations to link the module to the rest of the program. Such a module would reserve an appropriate amount of memory and map it directly to the 64K-byte address space of the 8085. Of course, if your version of Prolog (like Borland's Turbo Prolog) has built-in predicates to store and read the values of actual memory addresses, this is less of a problem.

Representing the Processor Architecture

The 8085, like its predecessor, the 8080, has eight addressable 8-bit registers. These are an accumulator (A), a flag register, and six general-purpose registers (B, C, D, E, H, L), which can be used as separate 8-bit registers or as 16-bit register pairs (BC, DE, HL). Although all three register pairs can be used as point-

continued

ers to addresses in memory, the HL register pair is used most often to reference memory addresses.

In addition to these eight registers, the 8085 also has a 16-bit program counter (PC), which always points to the address of the next instruction to be executed, and a 16-bit stack pointer (SP), which points to the bottom of the processor's downward-growing stack, located in RAM.

The 8085 uses the eighth register to store five 1-bit flags—zero, sign, parity, carry, and auxiliary carry—which note the results of executed instructions. The zero flag (Z) is set if the result generated by certain instructions is zero. The sign flag (S) reflects the state of the most significant bit in the accumulator following an arithmetic or logical instruction. The parity flag (P) is set if the number of bits set in the accumulator is even; otherwise, it is reset. The carry flag (CY) is set and reset by arithmetic operations, and the auxiliary carry (AC) flag signals an overflow from bit 3 to bit 4 of the accumulator.

Several of the 8085's instructions, including set interrupt mask (SIM), read interrupt mask (RIM), input byte (IN), output byte (OUT), and enable and disable interrupts (EI and DI, respectively), were not implemented because the simulated 8085 is not interruptible and has no I/O capability.

You can represent the 8085's registers and flags in several ways. For example, you can represent each register by its own predicate:

```
a(A).
b(B).
c(C).
```

Or you could group register pairs:

```
a(A).
bc(B,C).
de(D,E).
hl(H,L).
```

This way, you can recall the value of a register simply by calling the appropriate predicate with an uninstantiated argument. For example, entering the query

```
?- a(Y).
```

would elicit the response

```
Y = 0
```

if the accumulator contents were zero.

However, it is convenient to represent all the registers in one structure, since changing the value of a register is going to involve retracting the old predicate and asserting a new one (more about which later). The structure looks like this:

```
regs(A,B,C,D,E,H,L).
```

Similarly, the flags are represented with another simple predicate:

```
flags(Z,S,P,CY,AC).
```

Finally, these two predicates are part of a third, which includes the stack pointer registers and the program counter—in short, the overall state of the 8085:

```
state(regs(A,B,C,D,E,H,L),
      PC,SP,flags(Z,S,P,CY,AC)).
```

Using this technique, you can represent the architecture of nearly any processor. For example, the SAM had only a PC, an indirect address register (IAR), an accumulator, an indirect address buffer (IAB), and a status flag. Its architecture was represented with separate register and flag status predicates:

```
regs(PC,AC,IAR,IAB).
status(X).
```

Similarly, a 6510 could have its accumulator (A), X and Y registers, 2-byte program counter, 1-byte stack pointer, and associated flags represented as

```
state(regs(A,X,Y,PCH,PCL,S),
      flags(Neg,Oflow,Brk,
      IntDisble,Zero,Carry)).
```

Listing 1: *The monitor clause used in the simulator program. The clause consists of a repeat loop that prompts the user for input, "tokenizes" the input, parses the tokens, and then executes the command.*

```
monitor :-
   repeat,
   prompt,
   get_token_list(Tokens),
   ifthenelse( parse_tokens(Command,Tokens,[]),
          call(Command),
          write('invalid request')),
   fail.
```

Monitor

Simulating the 8085's architecture and instruction set and a chunk of read-write memory for it to interact with must be done through another piece of Prolog code—a monitor—that will show the user what's happening in simulated memory and the simulated 8085.

The monitor's job is to accept and execute commands the user inputs. The monitor I wrote for this project is pretty simple, accepting a handful of commands and hexadecimal numeric input.

There are three parts to the monitor: an input tokenizer, a set of grammar clauses to parse the tokens, and a set of routines to execute the command. These are reflected in the English-like description of the `monitor` clause in listing 1.

If you're new to Prolog, you might be raising an eyebrow at the `fail` predicate at the end of the main clause in listing 1. Why, you might ask, would you want something to fail? Actually, the `repeat` predicate at the start of the description and the `fail` at the end form a *repeat loop*, a looping control structure that takes advantage of Prolog's backtracking facility to cause a set of goals to be executed repeatedly. In operation, the goal `fail` (which always fails) deliberately forces Prolog to backtrack. When it backtracks to the `repeat` goal (which always succeeds), Prolog resumes forward operation by reexecuting the `prompt` predicate, which prompts the user for input.

The tokenizer converts the user input into a series of tokens. The tokenizer I used is a modified version of the tokenizer published in *Prolog Programming* by Claudia Marcus (reference 3). The major difference is that my version converts numerical input (assumed to be hexadecimal) to decimal before appending it to the list of tokens. This was done to bridge the gap between the hexadecimal notation used in the monitor input and the decimal requirements of the Prolog code.

Once the program has a list of tokens, it must parse, or examine, the list to see if it makes "sense." Fortunately, parsing is one of Prolog's strong suits, so much so that a grammar rule notation was developed as an aid for writing parsing routines. The grammar formalism implemented in Prolog is called definite clause grammar (DCG). This formalism is convenient for two reasons: It is capable of defining a language, and it can describe the process for analyzing that language.

The grammar I implemented is a simple one with a limited vocabulary. If you are not familiar with DCG notation, the following example should explain the gist of what's happening in the code. Take, for example, the clause

continued

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• Draw 5,000 Boxes	10.598	5.988
• Draw 3,200 Vertical Lines	9.391	4.949
• Draw 20,00 Horizontal Lines	15.766	5.551
• Fill 200 Circles	7.689	6.431
Math:		
• Integer Math	4.284	4.230
• Floating Point, Single Precision	8.184	1.805
• Sines and Cosines (7,200)	15.599	4.887
• Single Precision EXP	13.731	3.742
Matrix Operations:		
• Borland's Test	0.714	0.055
• Microsoft's Test	34.328	4.781
• Bubble Sort (1,000 Integers)	2.856	2.477
File I/O:		
• Sequential (2,000 records)	21.696	7.531
• Random (2,000)	52.234	51.078
Text I/O:		
• Secreen Mode 0 (5,000 characters)	0.934	1.750
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```
parse_tokens(change(Adr,Val))
          --> verb(change),
          address(Adr),
          byte(Val).
```

This clause says that if a list of tokens sequentially satisfies the three predicates on the right-hand side of the expression, then the predicate `parse_tokens` will succeed with its first argument instantiated to `change(Adr,Val)`. (Note that although only one argument is shown in this DCG clause, the actual arity (number of variables) of the `parse_tokens` predicate is 3. The reasons for this are beyond the scope of this article.)

The first clause on the right-hand side:

```
verb(change) -->
      [c];[ch];[change];[set].
```

is satisfied if the token is any one of the four listed (the ";" is Prolog's way of expressing the OR relation among clauses). This clause graphically underscores Prolog's flexibility, since including the synonym `set` for `change` is simply a matter of ORing it with the other synonyms for `change` on the right. The clause

```
address(Adr) --> [Adr],
       { Adr >= 0,
       top_of_memory(TOM),
       Adr =< TOM }.
```

appears more complicated but merely requires a token to satisfy the conditions inside the curly brackets before it is accepted as a valid address. In other words, the token `Adr` should be any number greater than or equal to 0 and less than or equal to the top of memory. Similarly, the clause

```
byte(Val) --> [Val],
       { Val >= 0,
       Val < 256 }.
```

requires a token to be a number between 0 and 255 for it to be a valid byte value.

If the `parse_tokens` predicate succeeds, the next step is to evaluate the goal returned by the `Command` variable in listing 1.

The Instruction Set

The 8085 implements a group of instructions that perform arithmetic and logical operations, conditional and unconditional branches and returns, and data transfers. Transfers can occur between registers, between registers and memory, and (though not implemented in the simulation) between registers and I/O ports.

The Prolog code for simulating the 8085 instruction set is the heart of the whole project, and it comprises the larg-

continued

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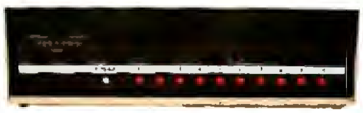

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est part of the code. Originally, I planned to simply write code for each separate instruction and forgo trying to generalize portions of it. However, the volume of the resulting code convinced me to look for ways of generalizing groups of instructions.

For example, the 8085 has an orthogonal set of Move instructions that permits data to be transferred from register to register and from a register to the address pointed to by the HL register pair. Simulating a move from register to register, say, from B to C, can be done as follows:

```
op( 72 ) :-
      retract(state(regs
      (A,B,_,D,E,H,L),
      PC,SP,Flags)),
      asserta(state(regs
      (A,B,B,D,E,H,L),
      PC,SP,Flags)).
```

This was, in fact, what my first attempt at simulating the Move instructions resembled. However, the problem with this approach is that this scheme must be repeated 63 times to cover all the possible register-to-register and register-to-memory transfers! Despite Arity/Prolog's virtual memory capabilities, having so many of these and other repetitive clauses slowed performance considerably.

The final form of the predicate for the Move instructions is given in listing 2. Even with the added predicates reg_ptr and move, the space saved by using this generalization is impressive. I estimated a savings of 20 percent in the overall size of the source file.

Note that, in this case, you are taking advantage of the source and destination information encoded in the instruction's binary value (bits 0 to 2 of the instruction identify the source, and bits 3 to 5, the destination) to find out what to do. If so inclined, you could rewrite the predicates for the instruction set to take account of the 8085's decoding operation.

After decoding the source and destinations, the reg_ptr goal maps these values to their positions in the regs predicate. You then call the goal move, which has four clauses corresponding to all possible combinations of register and memory data transfers. An attempt to move (mem,mem) is correctly interpreted as the processor's Halt instruction, and an appropriate message is printed on the user's screen.

Another notable example of generalization is the class of arithmetic and logical instructions, which provide for register contents to be added or subtracted from the accumulator. Their general scheme is (1) retract the processor's state, (2) perform the arithmetic/logical operation, (3) adjust the flags, and (4) assert the new processor state. The only variable to speak of here is the actual operation. In listing 3, by passing the operator to the goal acc_math, you take advantage of Prolog's ability to convert lists to callable structures. Here, you use the univ predicate (=..) to convert the list [Op,A,Reg] to the clause T1 = Op(A,Reg). Thus, we do not have to write separate clauses for each operation.

For the most part, however, implementing the other instructions was fairly straightforward.

Listing 2: *A generalized form of the clause that simulates the various Move instructions of the 8085. The clause uses an AND operation (/ \ ) to decode bits 0 to 2 (the source register) and bits 3 to 5 (the destination) of the Move.*

```
op( Code ) :-
     Code > 63, Code < 128,          % if so, this is a move.
     B210 is Code / \ 7,             % decode reg in bits 0-2.
     B543 is (Code / \ 56) >> 3,     % decode reg in bits 3-5.
     reg_ptr(B210,S),                % map to our representation
     reg_ptr(B543,D),                % in state/4.
     move(S,D).                      % do the move.
```

Listing 3: *A generalized clause used to emulate the processor's arithmetic and logical instructions. The clause* retracts *the processor's state, performs the arithmetic/logical operation, adjusts the flags, and* asserts *the new processor state. Note the use of Prolog's ability to convert lists to callable structures (using the univ predicate:* (=..) *without having to write separate clauses for each operation.*

```
acc_math(Op,Regname) :-
      retract(state(R,PC,SP,_)),
      arg(1,R,A),                    % first position in regs is accumulator
      reg(Regname,Place),            % find other reg's position
      arg(Place,R,Reg),              % get its value
      T1 =.. [Op,A,Reg],             % convert list to structure
      X is T1,                       % call it
      adjust_flags(A,X,Y,Flags),
      argrep(R,1,Y,NewR),            % replace old A with new
      asserta(state(NewR,PC,SP,Flags)).
```

Running the Simulator

Enough theory. Let's run the simulation.

Start by consulting the file START80.ARI. Once this file has been read in, typing in the goal go causes the remaining source files to be consulted and calls the monitor predicate.

At the "->" prompt, you can type in commands to step through an instruction; trace an instruction (like step, but it prints the processor state when finished); change contents of addresses, pointers, and registers; show the contents of memory and registers; reset the processor to some initial state; quit; or get help. To get detailed help for a particular command, type help <command-name>.

Parting Words

You can do much with this simulator. For one thing, its use is not limited to just the 8085. With appropriate modifications to the architecture and instruction-set predicates, you can use this simulator for a variety of devices and even to verify the design of some simple processors.

Simulating an 8-bit microprocessor in Prolog does not break any new theoretical ground in logic programming. It is neither whiz-bang nor state of the art, and it is most definitely not AI. There is not much here that couldn't have been implemented in C, Pascal, or BASIC. Nevertheless, the point of the exercise was to see whether the speed at which usable code could be developed warranted using Prolog to implement an essentially procedural program. I think it did. ■

[Editor's note: *The files that make up the 8085 simulation program are available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4.*]

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1. *Understanding Microprocessors*. Dallas, TX: Texas Instruments Inc., 1979.
2. *MCS-80/85 Family User's Manual*. Santa Clara, CA: Intel Corp., 1979.
3. Marcus, Claudia. *Prolog Programming*. Reading, MA: Addison-Wesley, 1986.

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Constraint Logic Programming

A new general framework for developing languages more powerful than traditional logic programming languages

Catherine Lassez

THE RECENT PROLIFERATION of extensions to logic programming languages such as Prolog reflects, on one hand, the popularity of these languages, and, on the other hand, their limitations.

The popularity of logic programming stems from its unique nature, which combines expressive and computational power with simple and clean semantics. Logic programming has the unique property that its semantics, operational and declarative, are both simple and elegant and coincide in a natural way. If the statements you write in a given Prolog program are correct and express what you want, the Prolog interpreter will give you the expected answer. In other words, what you see is what you get. The simplicity of Prolog semantics is remarkable when you consider other classic languages, where the semantics can fill entire textbooks.

This property, however, comes at a price. The semantics of a logic program are defined within the context of the Herbrand Universe—the set of all possible terms that can be formed from the constants and functions in a given program. In this universe, only those terms that are syntactically equivalent can be unified together. A problem arises when two terms are semantically identical but syntactically distinct.

For example, if you use the successor function (`s(x) = x+1`) and the factorial function (`fact(x)`), the terms `s(s(0))`, `s(fact(0))`, `s(fact(s(0)))`, and so on, all denote the number 2. To solve this problem, most Prolog extensions incorporate some equality theory and deal with arithmetic in an ad hoc way. To enlarge the class of possible applications, a new framework had to be defined.

Among the proposed extensions to Prolog, several versions incorporate other paradigms and/or languages. These include Loglisp (LISP and Prolog) and Funlog (Functional Programming and Prolog). The question arose, however, as to whether these extensions to Prolog preserved the logical basis of the language. For some researchers, the answer was no. Prolog II, for instance, was defined as a rewriting system in the domain of infinite trees and not as a logic programming language.

Very recently, however, J. Jaffar and J.- L. Lassez proved that it was possible to define languages in a more general logic framework, called the Constraint Logic Programming Scheme (see reference 1). Specific Prolog extensions, such as Prolog II and Prolog III, were then proven to be instances of the scheme. In consequence, these languages that were once thought to be outside the logic framework were brought back into it.

Constraints as a Programming Tool

Constraint solving is widely used in graphics, engineering, and knowledge representation because it allows great expressive power. Typically, we want to design systems over well-understood domains, such as sets, Boolean expressions, integers, rationals, real numbers, and so forth. These domains have natural algebraic operations associated with them. These operations include set or graph intersection, disjunction, or multiplication. The domains also have certain privileged predicates, such as set equality, graph isomorphism, and various forms of inequalities, such as set inclusion, $<$, $\neq$, $\geq$, and so on. It is these privileged predicates that we call *constraints*. Note that the various forms of equality are just a particular type of constraint.

The key property of constraints is that they allow you to define objects implicitly. Consider the following elementary example:

A set of names of people can be given explicitly as a list:

S = (John Doe, Barbara Smith, ...).

This same set can also be defined implicitly using constraints:

$$S = \{x : \text{salary}(x) > 35000 \ \& \ \text{status}(x) = \text{manager}\},$$

where S is the set of all x such that x has a salary greater than \$35,000 and is a manager.

The first definition is suitable for some simple operations, like mailing form letters. The second definition, however, conveys information that was not apparent in the first, and this information may be useful for other tasks.

continued

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The CLP scheme is not an extension to logic programming but provides a general framework from which Prolog extensions can be derived.

Implicit and explicit representations play important and complementary roles, and being able to pass from one representation to the other is a crucial problem in many fields.

Implicit representations are particularly important when you cannot obtain finite explicit representations. For instance, the set of points (x,y) defined by $x \neq y$, or $x \geq y$, cannot be represented explicitly. A listing of these points is out of the question.

The output from a Prolog program is strictly of the explicit type: $x = f(u,v)$, $y = g(u)$, for instance. On the other hand, a Prolog II output might contain constraints such as $x \geq f(u,u)$. The only way a Prolog program can output an explicit representation of this constraint is by generating an infinite listing.

The expressive power of constraints is particularly well illustrated when we talk about real numbers. You could argue that since we finitely represent numbers in computers, we need only rationals. However, equations like $x^2 = 2$, $x > 0$, or $\sin(x) = 0.5$, which represent real numbers, have no solutions in the rationals.

From a theoretical point of view, the case of real numbers is particularly challenging. In the standard logic programming theory, objects are represented as finite terms, and the set of terms is countable. But the set of real numbers is uncountable. The use of constraints helps circumvent this problem.

It is interesting to note that the unification algorithm, the key algorithm in Prolog, is a particular case of constraint solving. It tells us whether two terms, such as $f(x,a)$ and $f(b,y)$, can be made identical by a particular instantiation of the variables (here, $x = b$ and $y = a$). In other words, it tells us when the equation $f(x,a) = f(b,y)$ is solvable. In the process, it outputs a substitution that explicitly represents the set of all solutions. This finite explicit representation is a strength of unification, but it is also its weakness. For many domains of interest, such finite explicit representations do not exist, and therefore the concept of unification is not suitable.

The CLP Scheme

Before I describe the Constraint Logic Programming Scheme, let's consider a simple Prolog program. The factorial function is written in Prolog as

```
fact(N,F) :-N>0,
    fact((N-1),M),
    F=N*M.
fact(0,1).
```

A query such as

```
?-fact(3,F).
```

returns the answer F = 6. To achieve this answer, Prolog goes through a number of steps, which can easily be expressed in terms of solving constraints. In this process, four sets of constraints are obtained:

```
C1 = {3 > 0, F = 3 * M1}
C2 = C1 and {2 > 0, M1 = 2 * M2}
C3 = C2 and {1 > 0, M2 = 1 * M3}
C4 = C3 and {0 = 0, M3 = 1}
```

The first three sets of constraints come from the first clause of the program and have no explicit solutions. The fourth set, however, can be solved using the second clause, and its solution provides the answer.

It is therefore possible to look at a Prolog program from a constraint-solving angle. In fact, if you write a CLP program for the factorial, you will get the same program as above. However, there is a fundamental difference between the two: What happens, for example, if you reverse the function and ask for the number whose factorial equals 6? That is:

```
?-fact(N,6).
```

In this case, Prolog fails because the subtraction operation in Prolog works only if its arguments are instantiated, and the factorial program contains the expression N-1, where N has no value. Although it is possible to rewrite the Prolog program without this operator by using the successor function ($s(X) = X+1$), this creates different problems. In CLP, however, the problem does not arise, and you get the expected answer.

Note that the notion of constraints is independent of the nature of the parameters involved. At each step of the process, the interpreter has to deal with only a single question: Are the constraints solvable? For instance, the set of constraints {X >= 0, X + 1 > X}, which is always true, is handled correctly by Prolog only when X has a value; in CLP, the set of constraints is always solvable.

Like Prolog, the CLP scheme uses a syntax based on Horn clauses, which have the form

```
p(...) :-t1(...),..., tn(...).
```

where p is a predicate symbol and the t terms are either predicates or constraints. The constraints are composed of the terms in a particular domain of application, according to the operations defined in that domain.

Like logic programming, CLP uses the resolution principle, but the concept of syntactic unification in the Herbrand Universe is replaced by constraint satisfaction in the domain of application.

Note that the CLP scheme is not an extension to logic programming but provides a general framework from which many Prolog extensions can be derived. Each instance of the scheme is a CLP language with its own domain of application and constraint-solving mechanism. The main semantic properties, however, are inherited by each instance. It is important to note that this situation is the reverse of the usual one where the implementation of a language precedes its semantics.

CLP(*R*)

Although several extended Prologs have been shown to be in fact CLP languages, the first language developed within the CLP scheme was done by J. Jaffar and S. Michaylov at Monash University in Australia (see references 2 and 3). Their language, CLP(*R*), is an experimental implementation of the CLP paradigm in the domain of real arithmetic (*R*). It was developed on a Pyramid minicomputer running Unix.

Although most logic programming languages allow some arithmetic, this capability is an add-on feature, which falls outside the scope of the semantics of the language. In CLP(*R*), since the semantics are defined directly in the domain *R*, they are well-founded.

Consider the following CLP(*R*) program:

```
ohmlaw(V,I,R) :- V = I*R.
kirchoff(L) :- sum(L,0).
sum([],0).
sum([H|T], N) :-H + M = N,
   sum(T,M).
availres(10).
availres(14).
availres(27).
availres(60).
availres(100).
availcell(10).
availcell(20).
```

continued

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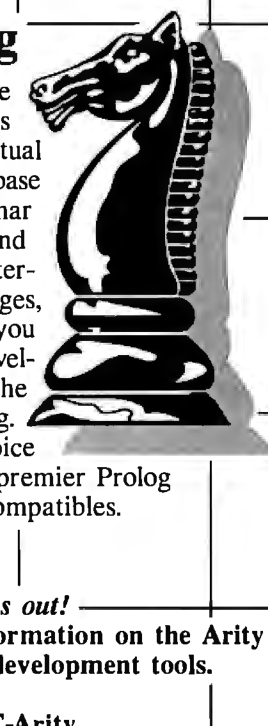

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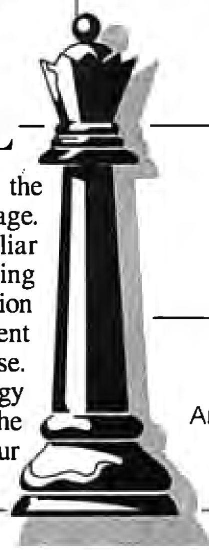

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Inquiry 15

Answering a goal is defined in terms of solvability of the set of constraints and not in terms of finding a value.

The first two clauses represent Ohm's law and Kirchoff's law; the next two define the sum of a list in the usual way, using head and tail notation. The rest is a small database of available resistors and cells. Let's construct a simple circuit of two resistors (R1 and R2) connected in series with a cell (V). Let's also suppose that the voltage over R2 should be between 14.5 and 16.5 volts. The goal given below asks for the possible values of the components in this list.

```
?-14.5 < V2, V2 < 16.25,
  availres(R1), availres(R2),
  availcell(V),
  ohmlaw(V1, I1, R1),
  ohmlaw(V2, I2, R2),
  kirchoff([I1, -I2]),
  kirchoff([-V, V1, V2]).
```

Each instance *a*, *b*, *c* of R1, R2, and V such that 14.5 < V2 < 16.25 gives rise to the problem: Is the following solvable?

```
V1/a - V2/b = 0
V1 + V2 = c
```

CLP(*R*) computes the three sets of solutions:

```
V = 20, R1 = 10, R2 = 27,
V = 20, R1 = 14, R2 = 60,
V = 20, R1 = 27, R2 = 100,
```

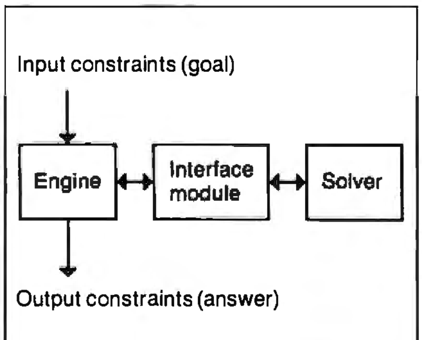

Figure 1: *A diagram of the CLP(R) interpreter, which contains a Prolog-like engine, a constraint solver, and a module that provides an interface between the two.*

Note that, in the definition of sum, the constraint H + M = N appears without any special symbol to differentiate it from the rest of the clause. Furthermore, it uses the variable M, which is defined only by the next term, sum(T,M). This would not be possible with most Prolog implementations because variables have to be instantiated before any expression containing them is evaluated. Even when Prolog has a delay mechanism, it typically requires the programmer to explicitly specify which evaluation should be delayed. In CLP(*R*), any necessary delay is done automatically, allowing more expressive power since the programmer can write clauses in the most readable format.

The constraints are formed of arithmetic terms in the usual way. Constraints in the domain of arithmetic provide a natural implicit representation for real numbers. For instance, with the previous example, the goal

```
?-ohmlaw(2,X,X)
```

succeeds in CLP(*R*) whereas it would fail in Prolog. Remember that CLP(*R*) deals with *real* arithmetic and not a rational approximation. CLP(*R*) also has the potential to produce symbolic output, as illustrated by the next example.

The predicate mortgage is defined in terms of the principal (P), the duration (Time), the interest rate (I), the monthly payments (MP), and the balance (B). The goal specifies values for the variables Time, I, and B, leaving CLP(*R*) to determine the other two.

```
mortgage (P, Time, I, B, MP) :-
      Time <= 1,
      B + MP = P * (1 + I).
mortgage(P, Time, I, B, MP) :-
      1 < Time,
      mortgage(P * (1 + I) - MP,
        Time - 1, I, B, MP).

?- Time=5, I=0.1, B=0,
   mortgage(P, Time, I, B, MP).
```

The answer, MP = 0.263797 * P, expresses the linear relation that exists between principal amount and monthly payment.

The expressive power of using constraints in queries as well as in answers is further illustrated by the next example, which deals with stock options. A stock option gives its owner the right to buy or sell a particular stock at a given price for a limited time. For instance, an XYZ July 50 *call* option is the right to buy 100 shares of XYZ stock at $50 per share until the July expiration date, regardless of the market price of the XYZ stock. Similarly, an XYZ July 45 *put* option is the right to sell 100 shares of XYZ stock at $45 per share.

The program given in listing 1 allows you to relate the underlying price of a stock (S) or bond (B) with the value of its option (Value), the price of a call (C) or put (P), the interest (I), and the exercise price (X). To find what the underlying price of a stock should be in order for the value of selling a call option to exceed 5, you could use the following query:

```
?- Value > 5, C = 5, X = 50, I = 0.05,
   value(call, sell, S, C, _, I, X, _,
   Value).

answer: S < 50 & Value = 5.25,
        50 <= S < 50.25 & Value
        = 55.25 - S.
```

The ability to return symbolic answers is a powerful feature of CLP(*R*). Answering a goal is defined in terms of solvability of the corresponding set of constraints and not in terms of finding a value.

Other similar but more powerful programs can also be written in CLP(*R*). For example, it is fairly straightforward to write a program that can calculate the theoretical price of an option. This can be done using the Black-Scholes formula, which calculates the theoretical price based on the underlying stock price, the exercise price, the time to expiration, the current interest rate, and the volatility of the stock. The value of such a CLP(*R*) program, however, is that you can also run the program *in reverse*. If you assume that the theoretical price is equal to the exercise price, you can then determine, say, the volatility. This is important because the data required for otherwise determining the volatility is not always available. (For more information on this program, see reference 4.)

The CLP(*R*) Interpreter

The CLP(*R*) interpreter, illustrated in figure 1, contains a Prolog-like engine, a constraint solver, and a module that provides an interface between the two. The engine is an inference mechanism that also recognizes the constraints and passes them to the interface. The engine can also solve some simple constraints. The interface evaluates complex arithmetic expressions and rewrites the constraints in a canonical form. The constraint solver solves constraints that cannot be handled by the engine or the interface; it also provides a delay mechanism for nonlinear constraints.

The following example illustrates with a simple program the role of the engine

continued

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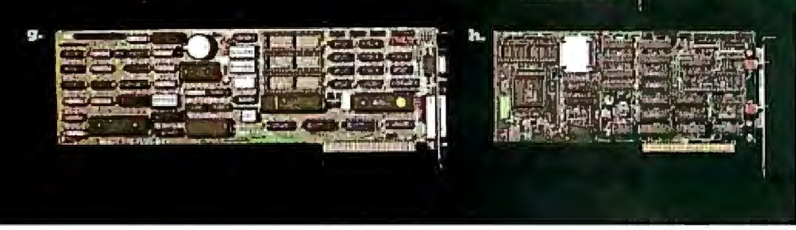

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Inquiry 261

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Constraint solving allows a natural representation of complex problems.

and of the interface in preparing the work for the solver:

```
p(S,T) :-  S + T = 8.
q(U,V) :-  U - V = 3.

?- p(X,Y), q(X,Y).
```

The engine produces the following sequence of equations:

```
X = S
Y = T
S + T = 8
X = U
Y = V
U - V = 3
```

The interface simplifies this set and sends to the solver only the following two equations:

```
X + Y = 8
X - Y = 3
```

The solver then returns the solution

```
X = 5.5, Y = 2.5
```

Given a set of constraints, the solver first determines the solvability of that set and, if solvable, computes the solution. There exist many algorithms to solve sets of linear constraints. CLP(*R*) uses a modified simplex method (for a presentation of this method, see reference 5). The processing of nonlinear constraints is delayed (i.e., temporarily suspended) until a sufficient number of variables are instantiated and the constraints become linear. It is the responsibility of the programmer, however, to ensure that this actually happens. In principle, these delay mechanisms could be avoided, as there exist nonlinear constraint solvers. But currently these algorithms are too inefficient.

After each derivation step of the inference engine, the solvability of the current set of constraints is determined by the solver (when a set of constraints is found to be unsolvable, the CLP(*R*) engine backtracks in the usual Prolog way). After the next step, new constraints may appear that are added to the previous set. Again, the solvability of the new set must be determined. An important feature of the solver is that it is incremental for linear equations. In other words, at each step, the engine works with a set of constraints in solved form, plus a single additional constraint. For linear inequalities, the problem is more complex, but classic simplex algorithms can be adapted. Nonlinear constraints are stored by the solver until they become linear, at which time they are evaluated for solvability with the current set. (A discussion of the CLP(*R*) solver can be found in reference 4.)

The Promise of CLP

Constraint solving is a powerful paradigm that allows a natural representation of complex problems. Constraint logic programming uses this paradigm to provide a general framework upon which powerful languages can be created. CLP(*R*) shows particular promise for solving problems for which no simple solutions exist.

I have shown how CLP(*R*) can be used to solve one type of problem: option trading. Other applications for CLP(*R*) have been investigated, and interesting applications have been reported in the domain of electrical engineering (see reference 6). These applications confirm the real usability of CLP(*R*) in areas that were up to now considered to be outside the range of logic programming languages.

Logic programming opened a new era in computing. Now, constraint logic programming should let us develop an exciting new wave of applications. ■

Listing 1: *A stock option valuation program written in CLP(R). The predicate* `value()` *relates the type of option* (`Type`), *your desired action* (`BuyOrSell`), *the underlying price of the stock* (`S`) *or bond* (`B`), *the price of the call* (`C`) *or put* (`P`), *the interest* (`I`), *the exercise price* (`X`), *and the value of the option* (`Value`). *The % sign indicates a comment.*

```
% Option valuation predicate
 value(Type, BuyOrSell, S, C, P, I, X, B, Value) :-
  check-parameters(S, C, P, I, X, B, Value),
  get-sign(BuyOrSell, Sign),
  data(Type, S, C, P, I, X, B, B1, B2, H1, H2, R1, R2),
  h(B1,S,T1), h(B2,S,T2), r(B1,S,T3), r(B2,S,T4),
  Value( = Sign * (H1*T1 + H2*T2 + R1*T3 + R2*T4).

% Heavyside function
 h(X,Y,Z) :- Y < X, Z = 0.
 h(X,Y,Z) :- Y >= X, Z = 1.

% Ramp function
 r(X,Y,Z) :- Y < X, Z = 0.
 h(X,Y,Z) :- Y < X, Z = Y - X.

% Safety check
 check-parameters(S, C, P, I, X, B) :-
  S >= 0, C >= 0, P >= 0,
  I >= 0, X >= 0, B >= 0.

% Buy or Sell sign
 get-sign(buy, -1).
 get-sign(sell, 1).

% Table data for call and put options, bonds, and stocks.
 data(stock, S, C, P, I, X, B, 0, 0, S * (1+I), 0,-1, 0).
 data( call, S, C, P, I, X, B, 0, X, C * (1+I), 0, 0,-1).
 data( put, S, C, P, I, X, B, 0, X, P * (1+I)-X, 0, 1,-1).
 data( bond, S, C, P, I, X, B, 0, 0, B * (1+I), 0, 0, 0).
```


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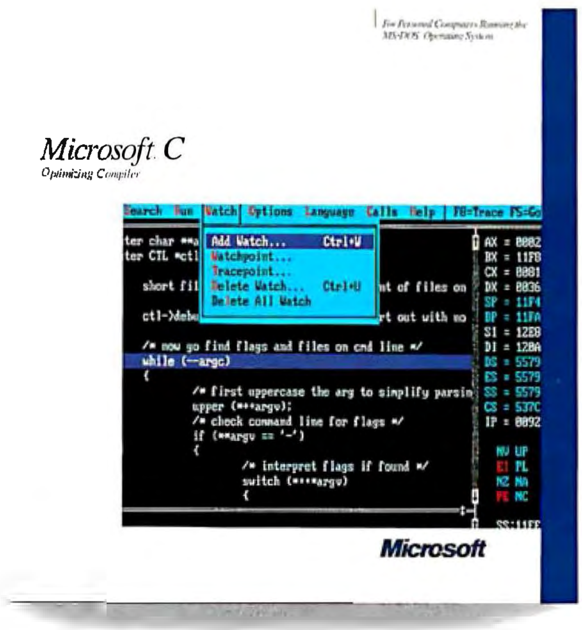

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Opening the Prolog III Universe

A new generation of Prolog promises some powerful capabilities

Alain Colmerauer

PROLOG WAS INITIALLY designed to process natural languages, but programmers now use it to solve problems in increasingly varied areas. These uses have emphasized its strengths but also made clear its limitations. You can bypass some limitations by using more efficient implementations and richer environments. But the fact remains that the core of Prolog—Alan Robinson's unification algorithm—has not changed in 15 years and is becoming less significant compared with an increasing number of external procedures.

The best examples of these external procedures deal with arithmetic processing, but they are difficult to use. To call them, you must be sure that certain parameters are known, and this clashes with the general Prolog philosophy that it is possible anywhere and at any time to talk about an unknown object x.

I therefore decided to fundamentally reshape Prolog by integrating the following features at Prolog's unification level: refined tree manipulation and list processing, complete processing of Boolean algebra (or propositional calculus), and number processing (+, *, >, =). As was the case for Prolog II, this reshaping consists of replacing the unification concept with the concept of *constraint resolution* in a specific domain with appropriate operations and relations.

I will describe the foundations of a new language, Prolog III, and illustrate its capacities with some examples.

Variables

In standard programming languages, each variable has a value. When you run a program, various assignment instructions successively modify these values. In Prolog III, a variable represents an unknown value. And when you run a Prolog III program, its aim is not to modify this value but to determine it.

For example, Prolog III can determine the value of x in a mathematical equation, such as

$$x = (1/2)x + 1.$$

Note that x can represent something more complex than a number; it can also represent a *tree*, such as in figure 1.

Note that the string is represented as a subtree of characters under the list symbol (< >).

Prolog III trees will be made up of nodes labeled by identifiers, a list symbol, Boolean values, rational numbers, or characters. I will adopt the convention here that an identifier is composed of several letters, while a variable contains only one letter. Trees whose first node is the < > symbol are lists. Boolean values are denoted by 1′ and 0′ [Editor's note: *Primes indicate that these are not numbers*], and fractions represent rational numbers.

The number of branches emanating from each tree node is finite, and these branches are ordered from left to right. Although I do not exclude the possibility that a tree could be made up of an infinite set of nodes, I will not deal with this point in this article.

A tree consisting of only one node is a leaf. I will not differentiate between a leaf and the label it carries. Therefore, I consider Boolean values and rational numbers as special types of trees.

To represent the trees, I will have at my disposal variables, constants, and operations. Therefore, a formula that includes these three elements will represent a tree. I will call this formula, considered as a syntactical object, a term.

Constants

Constants name certain types of trees. The several possible constants include identifiers (such as calculus12), the empty list (< >), Boolean values (0′, 1′), positive integers or zero, characters ('a,' 'B', '4,' '<'), and nonempty strings ('Dupont').

Note that numerical constants must be positive integers or zero. I can represent negative numbers and rational numbers by using the operations of division and negation. It is pointless to introduce a constant for the empty string, since such a string is the same as the empty list.

Operations

Operations construct trees from other trees. I have three types of operations at my disposal: Boolean operations, arithmetic operations, and operations to construct complex trees.

Boolean operations are defined only if

continued

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the operands are Boolean values. They are `not`, `and`, `or`, and `≡`. The `≡` operation produces a 1′ if the two operands are equal and a 0′ if they are not.

The arithmetic operations are defined only if the operands are rational numbers. The six such operations are the neutral operation, `a = +b`; change of sign, `a = -b`; addition, `a = b + c`; subtraction, `a = b - c`; multiplication, `a = 2 * b` or `2b`; and division, `a = b/2`.

For purposes of linearity, use of these operations will have certain restrictions. In a multiplication, only one of the two operands can contain variables. In a division, the second operand must not contain variables.

The construction operations make it possible to construct trees that comprise more than one leaf. The four types are list construction, `a = <b, c, d>`; tree construction, `a = b(c, d, e)`; general tree construction, `a = b[c]`; and list concatenation, `a = b • c`.

List constructions are defined for all possible types of trees. Tree constructions are defined only if the tree `b` is a leaf. General construction of a tree is defined only if tree `b` is a leaf and tree `c` is a list. Concatenation is defined only if the two trees `b` and `c` are lists.

Note that I can represent a list as `<e> • a`, where `e` is the first element of a list and `a` is the remaining part.

As with division and multiplication, I place an important constraint on list concatenation: If the operand on the left is a variable `x`, the length `n` of the list `x` must be known and explicitly specified by a constraint of the form `x:n`. In regard to this restriction, you should bear in mind that concatenation is an associative operation and that here I make no difference between `(x • y) • z` and `x • (y • z)`.

Relations

Prolog III uses a certain number of binary and unary relations. The binary relations are equality, `a = b`; inequality, `a ≠ b`; Boolean implication, `a => b` (if `a = 1` then `b = 1`); and numeric comparison, `a < b`, `a > b`, `a ≤ b`, `a ≥ b`.

Some examples of the unary relations include `a:fact` (the first node of tree `a` is labeled by an identifier), `a:list` (tree `a` is a list), `a:n` (tree `a` is a list of length `n`), `a:string` (tree `a` is a string), and `a:leaf` (tree `a` is a leaf).

Other examples of unary relations are `a:id`, `a:bool`, `a:num`, and `a:char`, which indicate that tree `a` is reduced to a leaf that is labeled by, respectively, an identifier, a Boolean value, a rational number, or a character.

Systems of Constraints

The first thing that Prolog III enables you to do is solve systems of constraints. These systems of constraints are finite sets of constraints that must all be satisfied at the same time. For example, to find out the number of pigeons (`p`) and rabbits (`r`) required to have a total of 12 heads and 34 legs, all you need to do is write the query

```
{p ≥ 0, r ≥ 0, p+r = 12,
  2p+4r = 34}?
```

and the machine will answer

```
{p = 7, r = 5}.
```

To compute a list `z` of 10 elements that will produce the same result no matter whether `<1,2,3>` is concatenated to its left or `<2,3,1>` is concatenated to its right, you merely need to write the query

```
{z: 10, <1,2,3> • z = z • <2,3,1>}?
```

The answer is

```
{z = <1,2,3,1,2,3,1,2,3,1>}
```

You can also solve both problems at the same time by asking

```
{p ≥ 0, r ≥ 0, z: 10,
 trio(p+r, 2p+4r, <1,2,3> • z) =
    trio(12, 34, z • <2,3,1>)}?
```

where `trio` is any identifier. The answer is

```
{p = 7, r = 5, z =
 <1,2,3,1,2,3,1,2,3,1>}.
```

The heart of a Prolog III interpreter will consist of a general algorithm for the resolution of these systems of constraints. This algorithm will first decide whether a system is solvable (i.e., whether it is possible to attribute values to its variables so that all the constraints are satisfied). Then, if the system is solvable, this algorithm will be used to simplify it so that its solutions (the values of its variables) become apparent.

These values can be unique, as in the previous examples, or multiple values might satisfy the constraints, as in the following example:

```
{0 ≤ x, x ≥ 3/4, x ≠ 1/2}.
```

If these values have no limits, the simplified system will be the empty system denoted by { }.

Note that the constraints-resolution algorithm replaces the unification algorithm used in a standard Prolog. Because of this, it must be very efficient and so reliable that it becomes a black box for the programmer. These two factors dictated my choice of operations and relations and the restrictions on multiplication, division, and concatenation. These factors have also made it too difficult to introduce a unary relation that would constrain a rational number to be an integer.

The Meaning of a Program for the Programmer

Now I will explain in broad terms what a Prolog III program is. Basically, it consists of a recursive definition of a subset of trees. Each element in this subset will be called a *deductible fact* of the program and represents a proposition that the programmer considers true. An example of such a proposition could be "Dupont is married and weighs 160 pounds," which was represented by my first example of a tree.

The set of deductible facts of a program is usually infinite and constitutes, in a way, an enormous database. You will see later that you can regard the execution of a program as a search through a fraction of this database. Of course, you cannot store this database in explicit form. It

continued

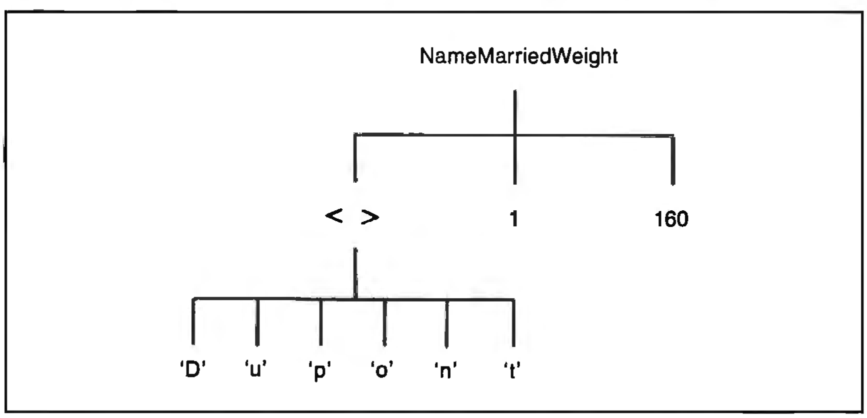
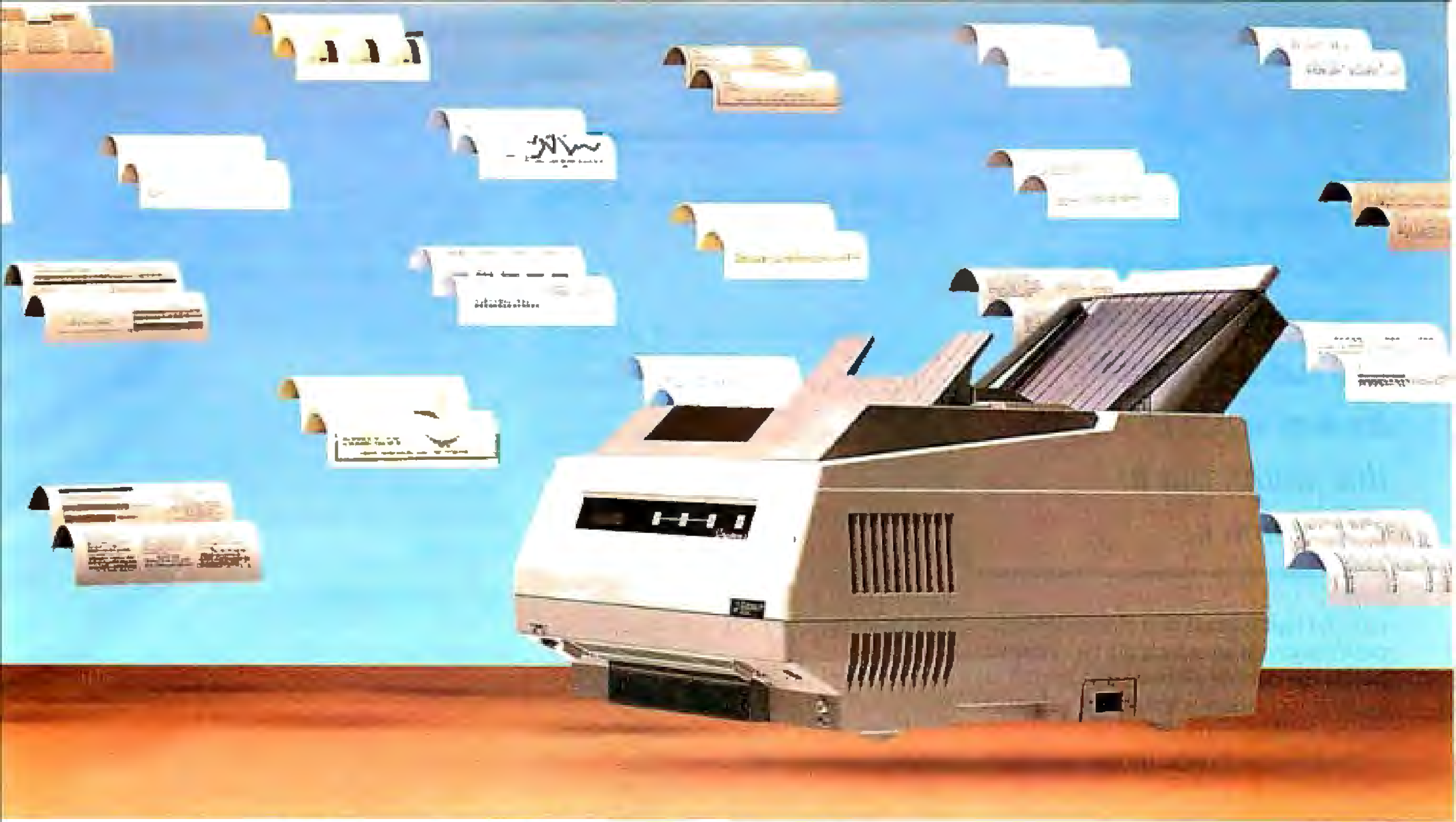


Figure 1: *An example of a tree representing a variable:* `NameMarriedWeight('Dupont',1,160)`.



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Inquiry 73

In Prolog III, a variable represents an unknown value. When you run a program, its aim is not to modify this value, but to determine it.

must be represented by a finite amount of information from which all the information in the database can be deduced. This finite information is the set of rules that makes up the program.

Each rule in Prolog III has the following form:

$t_0 -> t_1 \ldots t_n, S$

where $t_0 \ldots t_n$ are terms and where S is a list of constraints. Note that it is permissible to have only one term, t_0, or to have S be absent (in which case, it is considered an empty list). For my first example of a Prolog III program, see listing 1.

You can use this program to determine the components of a meal having a caloric content below a certain amount. Note that each food type has a specific caloric value.

The variables that appear in the Prolog III rules are quantified universally. In other words, each rule

$t_0 -> t_1 \ldots t_n, S$

Listing 1: *A short Prolog III program for devising light meals.*

```
LightMeal(a, m, d) ->
  Appetizer(a, i) Main(m, j)
  Dessert(d, k),
  {i>= 0, j >= 0, k >= 0,
   i+j+k <= 10};
Main(m, i) -> Meat(m, i);
Main(m, i) -> Fish(m, i);
Appetizer(radishes, 1) ->;
Appetizer(salad, 6) ->;
Meat(beef, 5) ->;
Meat(pork, 7) ->;
Fish(sole, 2) ->;
Fish(tuna, 4) ->;
Dessert(fruit, 2) ->;
Dessert(icecream, 6) ->.
```

is simply an abbreviated way of writing all the particularized rules

$a_0 => a_1 \ldots a_n$

You obtain these rules by giving the variables in the rule all the possible values that satisfy system S and transform the terms t_i into well-defined trees a_i. Here are a few examples of particularized rules for the first program:

```
LightMeal(salad,sole,fruit) =>
  Appetizer(salad,6) Main(sole,2)
  Dessert(fruit,2) ;

Main(sole,2) => Fish(sole,2) ;

Appetizer(salad,6) => ;
```

The process of particularizing rules is purely a mental one on the part of the programmer. The machine will not work in this way. On the contrary, when it uses the rules, it will try to keep them as general as possible. The advantage of particularized rules is that they do not use variables or constraints, and their meaning is therefore much clearer.

The fragments of the set of particularized rules from the previous program make it possible to replace the tree

```
LightMeal(salad,sole,fruit)
```

successively by

```
LightMeal(salad,sole,fruit) =>
Appetizer(salad,6) Main(sole,2)
  Dessert(fruit,2) =>
Main(sole,2) Dessert(fruit,2) =>
Fish(sole,2) Dessert(fruit,2) =>
Dessert(fruit,2) =>.
```

This tree is therefore a deductible fact of the program. If I now treat these fragments of particularized rules as logical properties, I conclude successively that the three sets below are made up of deductible facts of the program.

```
{Appetizer(salad,6), Fish
  (sole,2), Dessert(fruit,1)},
{Main(sole,2)},
{LightMeal(salad,sole,fruit)}.
```

Meaning of a Program for the Machine

I have now described the implicit information contained in a Prolog III program, but I have not yet explained how such a program is executed. The aim of the program's execution is to solve the following problem: Given a sequence of terms and a system of constraints, find the values of the variables that satisfy all the constraints and transform the sequence of terms into a sequence of deductible facts.

Two cases are of particular interest. First, if the sequence of terms is empty (or absent), the query can be restated as a request to solve the system of constraints. I have already given some examples of such queries.

Second, if the system of constraints is empty (or absent) and the series of terms consists of only one term, the request can be restated as follows: What are the values of the variables that transform this term into a fact that is deductible from the program?

If I now use the preceding example program, the query

```
LightMeal(a, m, d)?
```

will let me obtain all the sets of values for a, m, and d that constitute a light meal. In this case, there are six replies, including the following simplified systems:

```
{a=radishes, m=beef, d=fruit},
{a=radishes, m=pork, d=fruit},
{a=radishes, m=sole, d=fruit},
```

I can explain the method used to calculate the replies to a given query by using an abstract Prolog III machine. This is a nondeterministic machine whose function is described by three formulas:

1. $(W, t_0 t_1 \ldots t_n, S)$,
2. $s_0 -> s_1 \ldots s_m, R$
3. $(W, s_1 \ldots s_m t_1 \ldots t_n,$ $S \cup R \cup \{s_0 = t_0\})$.

Formula 1 represents the state of the machine at any given moment. W is a set of variables whose values I want to establish, $t_0 \ldots t_n$ is a sequence of terms that I am trying to delete, and S is a system of constraints that has to be satisfied.

Formula 2 represents the rule in the program that I am going to use to change the state of the machine. If necessary, I rename some variables of formula 2 so that none of them occur in formula 1.

Formula 3 is the new state of the machine after rule 2 has been applied. It is possible to progress to this new state only if the system of constraints in formula 3 has at least one solution in which each term is transformed into a well-defined tree.

To describe the actual functioning of the Prolog III machine, I can say that it starts from an initial state (where W is the set of variables that appear in the query) and calculates all the states that can be arrived at by repeating the above process. Each time I arrive at a state where the sequence of terms is empty, I simplify the system of constraints with which it is associated and provide this as an answer.

Differences between Marseille Prolog and Edinburgh Prolog

Rich Malloy

Prolog III and Prolog II are developments of the so-called Marseille school of Prolog. The Marseille style developed along slightly different lines than the more common Edinburgh style.

In the Marseille style, the "if" symbol ":-" is replaced by the arrow "->". No punctuation is used between the terms on the right side of a rule. And each fact or rule must end with a semicolon instead of a period. The "or" symbol ";" is not available. Nor are the special variable "_" and the arithmetic symbols such as "+", "-", and so on. Also, variables do not need to be capitalized, but they must begin with one and only one alphabetic letter; predicates and objects must begin with at least two letters. Comments appear in quotes. List members are merely separated by periods, with the first member being the head of the list, and the rightmost member representing the tail or the rest of the list. For example:

```
/* This is Edinburgh style */
is_member_of_list (X, [X|_]).
is_member_of_list (X, [_|Y]) :-
  is_member_of_list (X, Y).
avg(Value,X,Y,Z) :- Value is
  (X+Y+Z)/3.
```

```
''This is Marseille style''
is-member-of-list (x, x.y) ->;
is-member-of-list (x, u.y) ->
  is-member-of-list (x, y);
avg(v,x,y,z) ->
  val(div(add(add(x,y),z),3),v);
```

For more information on the Marseille syntax and Prolog II, see *Prolog* by F. Giannesini, et al., Addison-Wesley, 1986. Prolog II is available in the U.S. from ExperTelligence of Santa Barbara, California.

Rich Malloy is a senior technical editor for BYTE.

Now reconsider the example program, and apply this process to the query

```
LightMeal(a,m,d)?
```

The initial state of the machine is

```
({a,m,d}, LightMeal(a,m,d), {}).
```

By applying the rule

```
LightMeal(a',m',d') ->
  Appetizer(a',i)
  Main(m',j) Dessert(d',k),
  {i>=0, j>=0, k>=0, i+j+k<=10}
```

I progress to the state

```
({a,m,d}, Appetizer(a',i)
 Main(m',j) Dessert(d',k),
 {i>=0, j>=0, k>=0, i+j+k<=10
 LightMeal(a,m,d)=
   LightMeal(a',m',d')})
```

which simplifies to

```
({a,m,d}, Appetizer(a',i)
 Main(m',j) Dessert(d',k),
 {i>=0, j>=0, k>=0, i+j+k<=10,
 a=a', m=m', d=d'})
```

and then to

```
({a,m,d}, Appetizer(a,i)
 Main(m,j) Dessert(d,k),
 {i>=0, j>=0, k>=0, i+j+k<=10})
```

By applying the rule

```
Appetizer(salad,6) ->
```

I progress eventually to the state

```
({a,m,d}, Main(m,j) Dessert(d,k),
 {a=salad, j>=0, k>=0, j+k<=4})
```

In a similar way, I can apply the following two rules:

```
Main(m',i) -> Fish(m',i)
Fish(sole,2) ->
```

to get

```
({a,m,d}, Dessert(d,k),
 {a=salad, m=sole, k>=0, k<=2})
```

Finally, by applying the rule

```
Dessert(fruit,2) ->
```

I obtain

```
({a,m,d},,{a=salad, m=sole,
 d=fruit}).
```

I can conclude that the system

```
{a=salad, m=sole, d=fruit}
```

constitutes one of the replies to the query. To obtain the other replies, I proceed in the same way but using the other rules.

A Banking Calculation

In this example, the task is to calculate a series of successive installments that have to be made to repay an amount of money borrowed from a bank. I will assume a constant time period between installments and a 10 percent interest rate per period.

I can summarize the program for this calculation with two rules:

```
Payment(<>, 0) ->;
Payment(<i>•x, c) ->
    Payment(x, (1+10/100)c - i);
```

The first rule expresses the fact that it is not necessary to pay an installment if the amount owed is 0. The second, and recursive, rule states that a list of installments required to repay an amount c consists of an installment i plus the list of installments required to repay the amount c increased by 10 percent interest and reduced by installment i.

You can use this program in different ways. One of the most spectacular is to ask what three payments should be made to repay $1000 such that the second payment is twice the value of the first, and the third payment is three times the value of the first.

In other words, what value of i is required to have the sequence of installments <i,2i,3i> repay $1000? All you need to do is to write the query

```
Payment(<i,2i,3i>,1000)?
```

Here is an abbreviated trace of this calculation starting from the initial state

continued

```
({i}, Payment(<i,2i,3i>,1000),
 {}).
```

By applying the second rule of the program:

```
Payment(<i'>•x, c) ->
  Payment(x, (1+10/100)c-i');
```

I progress to the state

```
({i}, Payment(x,(1+10/100)c-i'),
 {Payment(<i,2i,3i>, 1000) =
   Payment(<i'>•x, c)}),
```

which simplifies to

```
({i}, Payment(x,(11/10)c-i'),
  {i'=i, x=<2i,3i>, c=1000},
```

then to

```
({i}, Payment(<2i,3i>, 1100-i),
 {}).
```

You can verify that when I apply the second and third rules again on this state, I will eventually obtain

```
({i}, ,{1331-(641/100)i=0}
```

which leads to a final response of

```
{i=207+413/641}.
```

In other words, i = $207.64.

Practical Realization

I want to finish this article with some information on the prototype for the Prolog III interpreter developed at my laboratory and at the company PrologIA.

The core of the Prolog III interpreter is essentially a nondeterministic machine with two stacks that are pushed or popped at the same time. In the first stack, you create all the structures that represent the states through which you pass. In the second stack, you store address-value pairs to record all the modifications you have made in the first stack, so you can make the necessary restorations for "backtracking."

From time to time, a general garbage collector removes the useless parts of the two stacks, while preserving their topographies. The core of the Prolog III interpreter also solves most of the equations and the constraints of the ≠ type.

The algorithms used are basically extensions of those used in Prolog II and described in reference 1. These extensions deal mainly with lists and numerical variables that are not constrained to be positive.

The core of the interpreter calls on two submodules: one for processing Boolean algebra and the other for processing numerical constraints of the ≠ type. Jean-Marc Boï and Frédéric Benhamou designed the module for Boolean algebra. The algorithms used are essentially those of Pierre Siegel (see reference 2). First, they check whether a system of constraints can be satisfied, then they simplify a given system into a system that uses only a given subset of variables.

The arithmetical module, written by Michel Henrion, processes variables that are constrained to be nonnegative (the reason for this is to remove the constraints of the greater-than-or-equal type). This module is based on George Dantzig's Simplex algorithm (see reference 3). A subtle process deals with "degeneracies" (appearances of zeros in awkward places). To this has been added a far-from-elementary process to deal with the remaining constraints of the not-equal-to type. The module also includes basic subprograms for carrying out addition and multiplication with infinite precision (using fractions whose numerator and denominator can have variable lengths).

The Future

A commercial version of the Prolog III interpreter or compiler should be available in the next few years. As my examples have shown, its applications will be varied, and my experience with Prolog tells me that most of these applications will be surprising.

I see, however, two dominant areas of interest. The presence of linear inequalities makes it possible to solve the traditional problems encountered in operational research (e.g., minimization of costs, planning, etc.). And the presence of Boolean algebra makes it possible to conceive smarter expert systems.

It is no longer necessary to limit reasoning models to the scheme "if that and that, then this." Logical uncertainties like "this or that is true" and logical negations like "this is not true" will now be possible. ■

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Logic Grammars

This feature of Prolog allows concise yet powerful programs for language processing

Stan Szpakowicz

PROLOG IS OFTEN presented as an artificial intelligence language. While AI is undisputedly an important area of application, Prolog is a language of choice for a much broader class of problems. One of these is language processing. You can write compilers and interpreters of programming languages—as well as natural-language interfaces—in Prolog in a succinct and readable manner. The notation that makes the writing of such processors particularly elegant is called logic grammars, or definite clause grammars (DCGs).

In this article, I will discuss logic grammars by using this notation to build a small compiler for a simple, hypothetical programming language. I will list parts of the code in the article; a complete listing is available (see the editor's note on page 195). The code described here runs under Arity/Prolog on the IBM PC and AAIS Prolog on the Macintosh.

The Parsing Problem

The heart of any language processor is a *parser*, or syntactic analyzer. This parser is based on a *grammar*, which specifies all correct expressions of the language.

The parser first checks the correctness of the input. If the input is correct, the parser might also return its structured representation. For example, the conditional statement in a Pascal-like language

```
if c < 0 then b := b + 1;
fi;
```

could be represented as the following structure:

```
if(cond(<, var(c), num(0)),
   s(let(b, expr(+, var(b),
   num(1))),
     skip))
```

Here, `fi` indicates the end of the `if` statement, `var(c)` represents the variable `c`, `num(0)` is the integer 0, `s(A,B)` represents a pair of statements `A` and `B` that are executed in order, and `skip` indicates "do nothing."

A parser typically does not bother with the individual characters of the input text. Instead, it takes as its input a sequence of *tokens*, also called *terminals* or lexical symbols. A *scanner*, or lexical analyzer, usually obtains this sequence of tokens from the source text. For example, you could give the original statement above to the parser as 13 tokens:

```
if id(c) < num(0) then id(b) :=
   id(b) + num(1) ; fi ;
```

Writing a scanner is a relatively simple task; later, I'll look at a neat method of doing this in Prolog.

For now, I will concentrate on parsing. To do this, I'll set up a hypothetical "Tiny" programming language. The grammar consists of the set of rules in listing 1.

In this grammar, each rule consists of a *left-hand side* and a *right-hand side*, separated by a '-->' symbol. The symbols in brackets are tokens; the others (called *nonterminal symbols*) are the names of larger syntactic constructions. You can read the grammar in listing 1 in the following way:

- A sequence of `statements` consists of either a statement, followed by a semicolon and another sequence of statements, or nothing.
- A `statement` is either a skip (a null statement), an assignment (a variable, a ":=" token, and an expression), an `if` statement (an `if` token, a condition, a `then` token, some statements, and a `fi` token), or a `while` statement (a `while` token, a condition, a `do` token, some statements, and an `od` token).

You can read the remainder of the rules similarly.

The parser confirms the correctness of a given sequence of tokens by imposing a structure upon it. For example, the sequence `id(b) := id(b) + num(1)` is a valid statement because `id(b)` and `:=` match the first two symbols in the second rule for `statement` and because the sequence `id(b) + num(1)` is a valid expression. You know it is a valid expression because `id(b)` is a primary (and thus, an expression), "+" is an arithmetic operator, and `num(1)` is a primary. Figure 1 shows this reasoning summarized in a graph.

The nodes in figure 1 correspond to boundaries between contiguous tokens. The arcs correspond to various meaning-

continued

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Listing 1: *Rules of the grammar of a hypothetical Tiny programming language.*

```
statements --> statement, [';'], statements.
statements --> [].

statement --> [skip].
statement --> [id(V)], [:=], expr.
statement --> [if], condition, [then], statements, [fi].
statement --> [while], condition, [do], statements, [od].

condition --> [not], relation.
condition --> relation.

relation --> expr, comp_op, expr.

comp_op --> ['='].
comp_op --> ['<'].

expr --> primary.
expr --> expr, arith_op, primary.

primary --> [id(V)].
primary --> [num(N)].

arith_op --> ['+'].
arith_op --> ['-'].
arith_op --> ['*'].
arith_op --> ['/'].
```

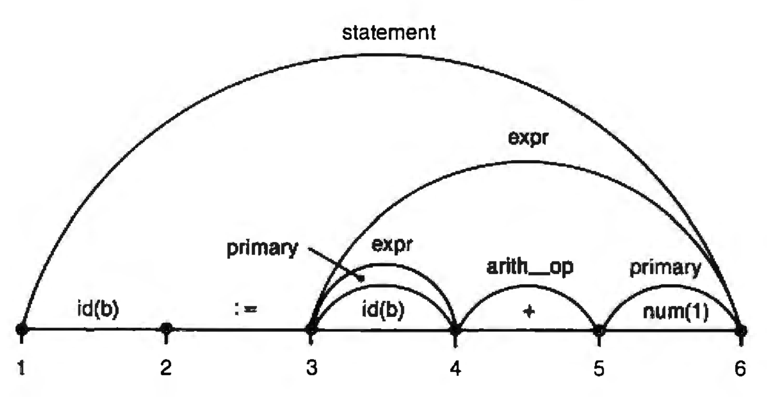

Figure 1: *A diagram showing how the syntactic constructions described in listing 1 are matched to the statement* "id(b) := id(b) + num(1)".

Listing 2: *Prolog clauses representing part of the grammar in listing 1.*

```
/*1*/ statement(K, N) :-
      token(id(V), K, L), token(:=, L, M), expr(M, N).
/*2*/ expr(K, L) :- primary(K, L).
/*3*/ expr(K, N) :- expr(K, L), arith_op(L, M), primary(M, N).

/*4*/ primary(K, L) :- token(id(V), K, L).
/*5*/ primary(K, L) :- token(num(V), K, L).

/*6*/ arith_op(K, L) :- token(+, K, L).
```

ful sequences of tokens; they are labeled with either nonterminal symbols or with tokens. Note that once you have represented the list of tokens in a line as in figure 1, you can see syntactic analysis as adding the appropriate arcs, as dictated by the rules of the grammar.

Parsing in Prolog

You can represent the graph in figure 1 as a series of clauses in Prolog:

```
token(id(b), 1, 2).
token(:=, 2, 3).
token(id(b), 3, 4).
token(+, 4, 5).
token(num(1), 5, 6).

primary(3, 4).
expr(3, 4).
arith_op(4, 5).
primary(5, 6).
expr(3, 6).
statement(1, 6).
```

In each clause, node numbers are used as parameters. You can express the last six clauses, which correspond to nonterminal symbols, in a different way if you make use of the appropriate grammar rules. Here are some examples:

```
expr(3, 6) :- expr(3, 4),
  arith_op(4, 5), primary(5, 6).
expr(3, 4) :- primary(3, 4).
arith_op(4, 5) :- token(+, 4, 5).
```

These clauses mention specific node numbers, but *any* primary is an expression, not only that extending from node 3 to node 4. Creating a more general clause is straightforward, and a list of these clauses appears in listing 2.

In this listing, variables have replaced node numbers in each clause. Actually, you can use any unique name in place of node numbers. Even a list will do. One possible list to use is the list of tokens to the right of the token being analyzed. For example, you can replace the clause

```
token(id(b), 1, 2).
```

with the more general

```
token(id(b),
    [id(b),:=,id(b),+,num(1)],
    [:=,id(b),+,num(1)]).
```

Here, I have replaced the numbers 1 and 2 with two lists. Note that the first list contains all the tokens in figure 1. The second list contains all the tokens to the right of the first token.

If I use Prolog's list notation `[T | Ts]`, where `T` is the first token of a list and `Ts` is

continued

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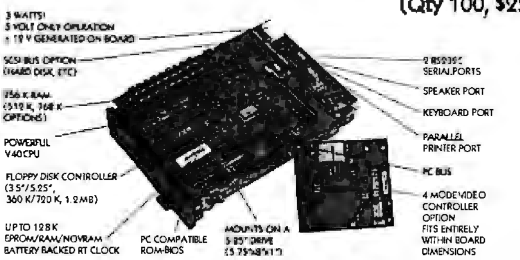

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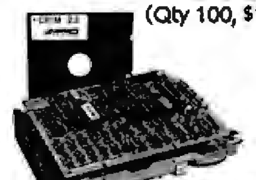

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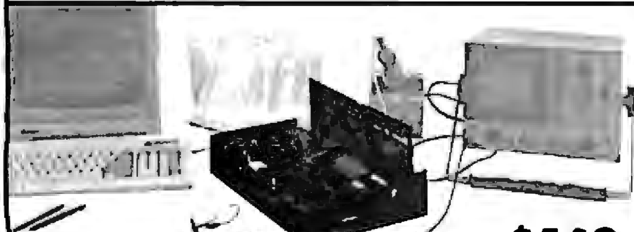

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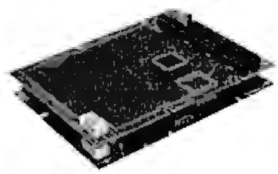

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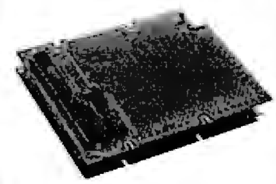

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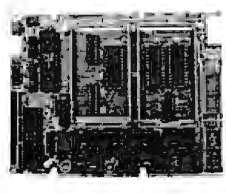

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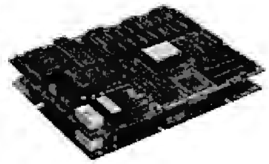

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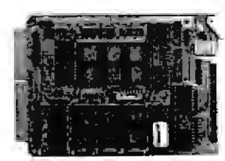

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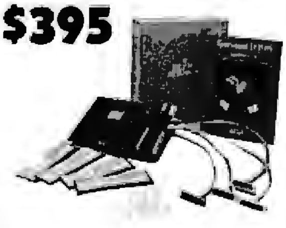

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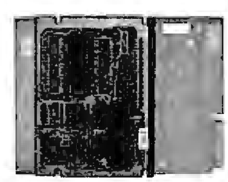

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Listing 3: *An almost complete parser of the Tiny language, written using grammar rules. Note the similarity to listing 1.*

```
program(s(Stmt, Stmts)) -->
      statement(Stmt), [';'],
      statements(Stmts).

statements(s(Stmt, Stmts)) -->
      statement(Stmt), [';'],
      statements(Stmts).
statements(skip) --> [].

% a sequence of statements is represented as a nested term,
% for example, s(Stmt1, s(Stmt2, s(Stmt3, skip))),
% where Stmt1, Stmt2, Stmt3 represent individual statements

statement(skip) -> [skip].
statement(let(V, E)) --> [id(V)], [:=], expr(E).
statement(if(C, Stmts)) -->
      [if], condition(C), [then], statements(Stmts), [fi].
statement(while(C, Stmts)) -->
      [while], condition(C), [do], statements(Stmts), [od].

condition(not(C)) --> [not], relation(C).
condition(C) --> relation(C).

relation(cond(Op, E1, E2)) --> expr(E1), comp_op(Op), expr(E2).

comp_op('=') --> ['='].
comp_op('<') --> ['<'].
```

the list of all tokens to its right, I can generalize the above clause to form the seventh clause, to be added to those from listing 2:

```
/*7*/ token(T, [T | Ts], Ts).
```

I am now ready to demonstrate parsing at work. Returning to figure 1, I can check whether this list of tokens is a statement by checking if the goal

```
statement(K,N)
```

from clause 1 could be satisfied. Before I make this call, I must instantiate K to be the complete list of tokens. As you saw above, the variable N refers to all tokens to the right of the tokens being analyzed. Since I want to analyze all tokens in the list, N will be empty. I would thus use the call

```
statement([id(b),:=,id(b),+,
  num(1)], [])
```

The execution of this call, based on clauses 1 through 7, would generate a number of other calls, including

```
token(id(V),
  [id(b),:=,id(b),+,num(1)],
     L'),
  token(:=,L',M'),
  expr(M',[])
token(:=,
    [:=,id(b),+,num(1)],M'),
  expr(M',[])
expr([id(b),+,num(1)],[])
```

In all these calls, the last two arguments have an intuitive interpretation. The second-to-last argument, referred to as the "input" argument, is the sequence of tokens remaining to be recognized before the call is activated. The last argument (the "output") is the sequence that will remain to be recognized after the call has succeeded. These input and output arguments will be called *ioargs* for short.

The list difference between an input and output argument is the construction or token being analyzed. For example, the call

```
expr([id(b),+,num(1)],
  [+,num(1)])
```

means "take the difference between the list [id(b), +, num(1)] and the list [+, num(1)] and recognize this difference [id(b)] as an expression." Similarly:

```
expr([id(b),+,num(1)], L)
```

means "take the list [id(b),+,num(1)], recognize some expression at its beginning, and instantiate L as the list of tokens remaining." Note that this call is nondeterministic: Depending on which expression is recognized at the beginning of the list, L may be equal to either [+, num(1)] or [].

Grammar Rules

The essence of clauses 1 through 6 in listing 2 is structural information. For instance, according to clause 1, a statement can consist of an identifier, a := token, and an expression. Fortunately, Prolog has a special notation called a *grammar rule* that emphasizes this information. Here is an example of a Prolog grammar rule equivalent to clause 1:

```
statement --> [id(V)], [:=], expr.
```

Prolog dialects that support logic grammars treat this rule as a unit clause with the name '-->' and two parameters (the left-hand and right-hand sides of the rule). The rule is read in, processed, and stored as an ordinary Prolog clause.

If you refer to the original grammar in listing 1, you will find that it is composed of grammar rules and is a logic grammar. My hypothetical Tiny language is described in perfectly correct Prolog.

Grammar Rule Parameters

Parsers can determine whether input text is syntactically correct. But they are also expected to output a representation of the input's structure. To construct this representation, a Prolog parser must be able to instantiate variables. In other words, its clauses need to have other arguments in addition to the ioargs.

The following clause, which recognizes assignment statements, shows how this need is usually met:

```
statement(let(V, E), K, N) :-
  token(id(V), K, L),
  token(:=, L, M),
  expr(E, M, N).
```

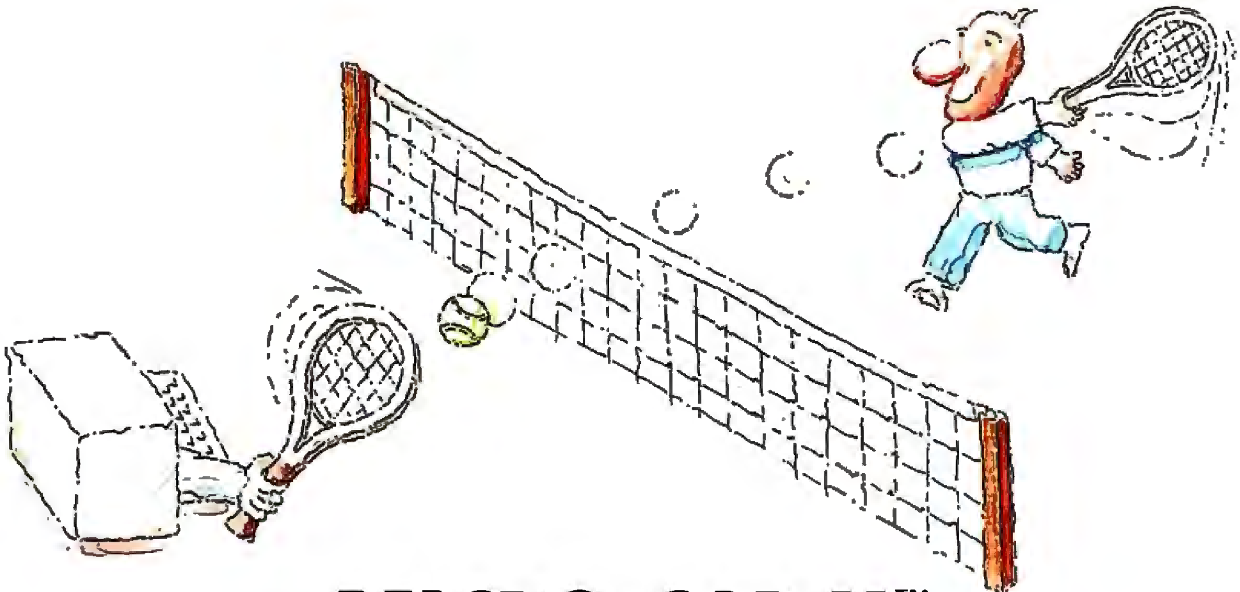
The first argument, let(V, E), represents the structure of an assignment statement, where V is the name of the variable to which a value is assigned and E is the representation of the expression providing this value. Note that instantiations of V and E are obtained during the normal operation of the parser. The structure let(V, E) is then a desired "additional effect."

You can express this clause more simply as a grammar rule. Note how the ioargs (K, L, M, and N) are again suppressed:

```
statement(let(V, E)) -->
  [id(V)], [:=], expr(E).
```

Listing 3 is an almost complete parser of the Tiny language. This listing is a

continued



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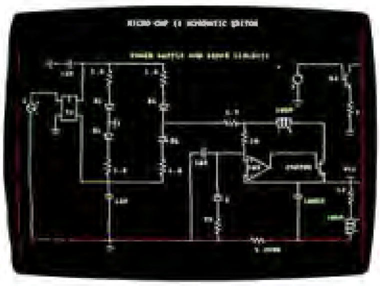

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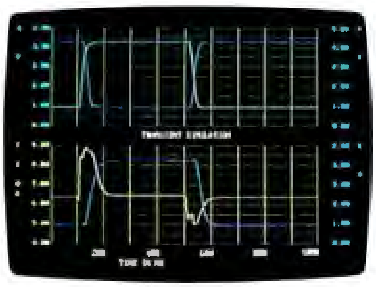

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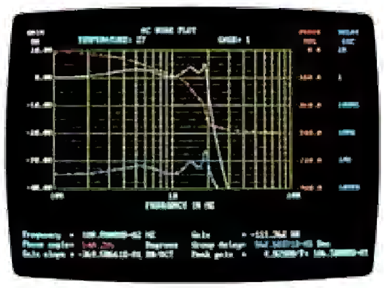

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straightforward extension of the parameterless grammar from listing 1.

Rules for expressions are missing from listing 3. This is because the rule

```
expr --> expr, arith_op, primary
```

would be processed and stored as a left-recursive clause, never welcome in Prolog programs. Rather than abstractly explaining methods of avoiding left recursion in grammars, I have provided one solution for this, which is included in the complete listing of the compiler.

Conditions and Actions

The grammar rules I have discussed so far are all processed and stored as clauses whose predicates have ioargs. These ioargs are thus safely shielded from inexpert use. It is also possible, however, to have Prolog calls that do something useful without touching ioargs.

A good example is the *cut* (!), a frequent, although not always desired, guest in Prolog code. Adding a cut is simple. The rule

```
statements(s(Stmt, Stmts)) -->
     statement(Stmt), [';'], !,
     statements(Stmts).
```

will be translated as

```
statements(s(Stmt, Stmts), K, N) :-
   statement(Stmt, K, L),
   token(';', L, M),
   !,
   statements(Stmts, M, N).
```

The effect of the cut here is to speed up the parser.

Once the parser recognizes a list of tokens as, say, an assignment statement followed by a semicolon, it will not attempt to recognize these same tokens as an `if` or a `while` statement.

You might also wish to perform an operation that is not expressible by unification. These calls must be "wrapped" in curly brackets in order not to be confused with nonterminal symbols. For example, the rule

```
octal_digit(Oct) -->
     [Oct],
   { 48 =< Oct }, { Oct =< 55 }.
```

translates into the clause

```
octal_digit(Oct, K, L) :-
   token(Oct, K, L),
   48 =< Oct, Oct =< 55 .
```

This rule recognizes any ASCII character between 0 (ASCII 48) and 7 (ASCII 55) as an octal digit. You can interpret this as a rule with *conditions* that must hold if the token is to be accepted.

As another example, consider the rules

```
lsym(num(N)) -->
      digit(D),
   digits(Ds),
   { name(N, [D | Ds]) }.
digits ([D | Ds]) -->
   digit (D), digits (Ds).
digits ([]) --> [].
digit (D) -->
   [D],
   { 48 =< D }, { D=< 57 }.
```

These rules are part of a scanner for our language processor. The rule for `digit` recognizes a digit given its ASCII code. The rules for `digits` recognize a sequence of digits and build a list of their ASCII codes. The rule for `lsym` recognizes a sequence of digits as an integer and builds the term `num(N)`, where `N` is the value of the integer. Note that I use Prolog's built-in operation `name`, which can convert a name or integer into a series of ASCII codes and vice versa. You can

continued

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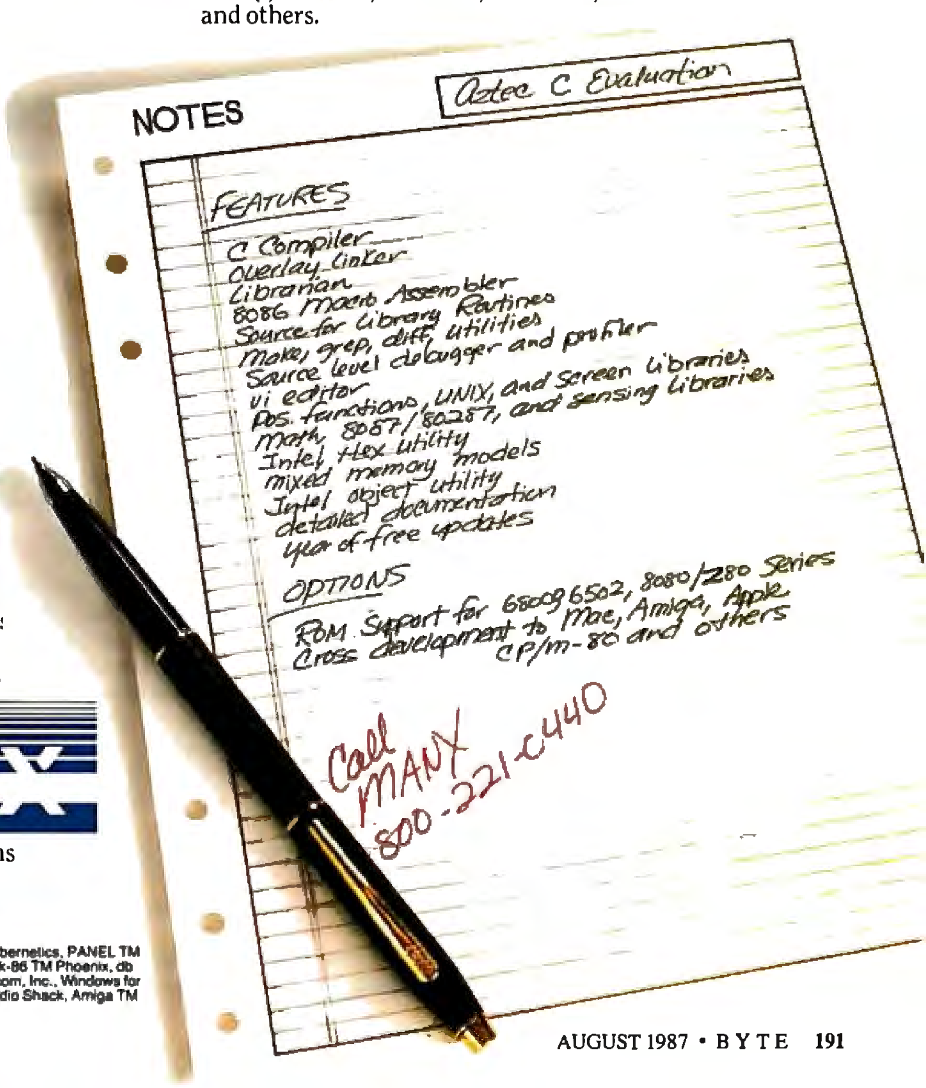

Listing 4: *The top level of a code generator for the Tiny programming language. Note how the parameters of the grammar rules here correspond to the parameters of the rules in the parser, listing 3.*

```
interm_code(s(Stmt, Stmts)) -->
        interm_code(Stmt), interm_code(Stmts).
interm_code(skip) --> [].
interm_code(let(V, E)) -->
        expr_interm_code(E), [store(V)].
interm_code(if(C, Stmts)) -->
        { newlabel(L) },
        cond_interm_code(not(C)),
        [jmp_cond(L)],
        interm_code(Stmts),
        [label(L)].
interm_code(while(C, Stmts)) -->
        { newlabel(L1) }, { newlabel(L2) },
        [label(L1)],
        cond_interm_code(not(C)),
        [jmp_cond(L2)],
        interm_code(Stmts),
        [jmp(L1)], [label(L2)].
```

program the entire scanner in a similar manner. [Editor's note: *You will find the complete scanner included with the full listing of the program.*]

Code Generation

I have now talked about two of the three phases of a small but complete compiler of the Tiny programming language: the scanner and the parser. I will now describe a code generator that translates the parser's output into an abstract machine-level target language. Once more, I express it as a grammar. But first, here is how the three phases will interact:

```
compile :-
  read_in(Chars),
  lsym_list(LexSyms, Chars, []),
  program(Tree, LexSyms, []),
  interm_code(Tree, Code, []),
  write_out(Code).
```

The source program is first read in as a list of ASCII codes. It is then given to the scanner, indicated by the predicate `lsym_list`.

A list of tokens (`LexSyms`) is produced and given to the parser (`program`), which builds the syntactic structure of the source program (`Tree`). The code generator (`interm_code`) then generates intermediate code (`Code`). A realistic compiler would then optimize the code and assemble it into an actual machine language program—an exploit beyond the scope of this article.

Note that the call

```
program(Tree, LexSyms, [])
```

refers to the clausal form of the first rule in the parser (see listing 3). The parameters `LexSyms` and `[]` represent the ioargs that the Prolog interpreter added when the rule was processed.

My version of the code generator draws upon the "multiusability" of Prolog programs. There is no reason why grammar rules should only read lists of tokens and return structures. A Prolog grammar can also be run "backward," generating a token sequence from a given structure.

The idea is simple: I write a grammar of a simple target language, just as I wrote grammars of token sequences and programs in the Tiny language. But then I use it in reverse to generate a list of tokens rather than to group the tokens together in a syntactic structure.

By way of illustration, listing 4 is the top level of such a grammar, with five rules corresponding to five types of statements in the parser in listing 3. Here is a clear "structural" reading given for the first four rules:

- The code for a sequence of statements consists of the code for the first statement, followed by the code for the subsequent statements.
- Nothing is generated for the null statement.
- An assignment statement is translated into code that evaluates the expression, leaves its value in the accumulator, and stores it.
- An `if` statement is translated into code that creates a label name, evaluates the negated condition, and sets the condition register; this code is followed by a conditional jump to the new label, the code to be executed if the condition is true, and finally the new label.

continued

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Listing 5: *Sample data and results processed by the Tiny compiler. Although it is unoptimized and was written in less than 200 lines, the compiler is quite powerful.*

The source program:

```
x := a; y := n; z := 1;
while not i < 1 do
  if y / 2 * 2 < y then
   z := z * x;
  fi;
  x := x * x;
  y := y / 2;
od; #
```

The resulting object code:

```
load(a)
store(x)
load(n)
store(y)
loadc(1)
store(z)
label($lbl1)
loadc(1)
store($mem1)
load(i)
sub($mem1)
tst_neg
jmp_cond($lbl2)
load(y)
store($mem2)
loadc(2)
store($mem3)
loadc(2)
store($mem4)
load(y)
div($mem4)
mul($mem3)
sub($mem2)
tst_neg
flip
jmp_cond($lbl3)
load(x)
store($mem5)
load(z)
mul($mem5)
store(z)
label($lbl3)
load(x)
store($mem6)
load(x)
mul($mem6)
store(x)
loadc(2)
store($mem7)
load(y)
div($mem7)
store(y)
jmp($lbl1)
label($lbl2)
```

You can write the rest of the code generator similarly. I wrote the Tiny compiler discussed here with logic grammars in less than 200 lines. Another 100 lines would make it even more realistic. To see how powerful it is, despite its limitations, consider the data and results in listing 5.

Conclusions

Logic grammars are a succinct and powerful notation for language processing. A grammar is both a language specification and a processor (scanner, parser, or code generator). Prolog grammar rules mix freely with ordinary clauses, so you can enjoy all the advantages of Prolog as a high-level programming tool while developing a grammar application.

Some, but not all, Prolog dialects support grammar rules. Every grammar could be manually coded as ordinary Prolog clauses, but the clarity and readability of the program would suffer. It would also be easy to write a preprocessor in Prolog (the books I cite describe such preprocessors), but the pleasure of using this powerful notation would be marred by having to juggle two different forms of your programs. If you plan to seriously work with logic grammars, use a dialect in which they are built-in.

I have not touched on natural-language processing, an even more important application of logic grammars. You can find a brief introduction in references 1 and 3. For serious readers, I recommend chapter 5 of the book in reference 4.

This presentation is based on my book (see reference 2), where you can also find some programming hints and a larger example: an interpreter of a query language implemented with logic grammars. The book by Sterling and Shapiro (see reference 3) presents a larger compiler, implemented in a slightly different manner. ■

[Editor's note: *The source code listings for this article are available as the files SZPAK.LST and SZPAK.BNL on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4.*]

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Reviews

REVIEWER'S NOTEBOOK

Our plan this month was to entice you with early looks at two new and competing C compilers: Borland's Turbo C and Microsoft's Quick C. At press time, however, Microsoft's product was still at too preliminary a stage for testing; we'll save Quick C for an upcoming issue. This time, BIX senior editor David Betz gives his impressions of Turbo C and some benchmark results below.

Here's the final update on our April dot-matrix printer review: Technical editor George Stewart rounded up the last of the printers that couldn't be tested in time for the review and came up with the following benchmark results. The Mannesmann Tally MT-490 logged in throughput for draft, near-letter-quality (NLQ), and graphics modes at 269, 126, and 421 characters per second (cps), respectively; the Genicom 3410.02 came in at 197, 86, and 558 cps. On a scale of 1 to 5 (5 being the best), the MT-490 received ratings of 2, 3, and 3 for print quality in draft, NLQ, and graphics modes; the Genicom 3410.02 pulled in ratings of 3, 4, and 4, respectively. Finally, sound levels for the MT-490 in these three modes measured 72, 71, and 74 decibels (dB); the Genicom 3410.02 measured 72, 72, and 75 dB. For an explanation of the tests and additional information on these printers, please refer to the April review.

—Cathryn Baskin
Senior Technical Editor, Reviews

Borland's Turbo C version 1.0 is an inexpensive ($99.95) and fast integrated programming environment for the C programming language that runs on the IBM PC, XT, AT, and true compatibles. It combines an editor with a compiler, linker, and a `MAKE` facility. It supports six different memory models (tiny, small, medium, compact, large, and huge), as well as mixing of models. All program development can be done from within the single integrated environment.

Because many C programmers prefer a command-line environment, Borland includes a command-line version of the compiler, as well as a Unix-style `MAKE` utility. Even when you run it from the command line using `MAKE`, Turbo C is very fast. This dual approach virtually guarantees that all programmers will find what they're looking for in Turbo C. The compiler requires one floppy disk drive, 384K bytes of RAM, and DOS 2.0. (It's available from Borland International, 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438-8400.)

To take a quick look at how Turbo C compares with other C development systems, I chose a relatively large program to use as a benchmark: XLISP 1.7, which consisted of approximately 15K lines of C code in 22 source modules. The total line count as reported by Turbo C was about 20K bytes, but this includes multiple copies of the include files. I used a Compaq Portable 286 running at 8 MHz with 640K bytes of memory and a 20-megabyte hard disk for the Turbo C benchmark tests. For the Lightspeed C tests, I used a Macintosh SE with 1 megabyte of memory and a 20-megabyte hard disk. I used the large memory model under both Turbo C and Microsoft C.

Table 1 illustrates the performance of Turbo C compared with that of the Microsoft C Compiler 4.0 and Think Technologies' Lightspeed C compiler 2.01 for the Macintosh. The Compile and Link test measures how long it takes to compile and link all 22 XLISP source modules and produce an executable file. The Recompile and Link test measures how long it takes to recompile a single file and relink the entire program generating an executable file. This second test is important because much of program development consists of making a change to a module and recompiling to test the change. Turbo C does quite well here, which should make the edit/compile/link/test cycle much shorter.

You might be tempted to guess that Turbo C achieves compile speed at the expense of execution speed and code size. Remarkably, it doesn't. Turbo C generated a smaller executable module than Microsoft C, and the resulting code runs slightly faster. To test execution speed, I chose a fairly common LISP benchmark and compared the execution times of the benchmark run under the versions of XLISP compiled with each of the compilers. Turbo C definitely comes out ahead of Microsoft C here (I used the compiler options for both compilers to optimize execution speed).

I ran into a few problems with Turbo C, however. A bug in the large model run-time library in version 1.0 causes a `fixup overflow` error during the linking of XLISP. The problem occurs only with large programs; Borland says it happens only with large model programs with more than 64K bytes of code. I got around this error by linking with the 8087/80287 libraries, but I was unable to generate a working version of XLISP for machines without numeric coprocessors. I spoke with Borland about this problem and was told that a fix was coming, but it didn't arrive in time for me to evaluate it for this article.

In sum, Turbo C is a fast, easy-to-use, and flexible programming environment. It's much faster at compiling and linking than most other competing packages and generates code that is just as good. The main feature that it lacks is a symbolic debugger. If this were added, Turbo C would be a nearly ideal C development system. Even in its current form, Turbo C is fast enough to make the traditional approach of inserting `printf` statements a practical way to debug C programs. With a fix for the `fixup overflow` bug, Turbo C will definitely be a package to consider when you're looking for a C development system for the IBM PC and compatibles.

—David Betz
Senior Editor, BIX

Table 1: *Benchmark results. See text for an explanation of the tests. All times are in seconds; file sizes are in bytes. TC = Turbo C's integrated environment; TCC = Turbo C's command-line version; MSC = Microsoft C 4.0; LSC = Lightspeed C 2.01.*

	TC	TCC	MSC	LSC
Compile and Link	2:38	3:22	14:20	2:31
Recompile and Link	0:24	0:26	1:54	0:14
Execute `tak.lsp`	5:12	5:12	5:20	6:18
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The Macintosh SE

Laurence H. Loeb

Apple's Macintosh SE (which stands for system enhanced) is the top of the "classic" Macintosh product line. It provides some of the same features as the Mac Plus: an 800K-byte floppy disk drive, 1 megabyte of memory (standard), and a SCSI port. However, a number of internal modifications make the Mac SE superior to the Mac Plus in performance and reliability. The most important feature of the Mac SE may be its single internal expansion-board connector. This allows you to connect additional hardware to enhance the capabilities of the Mac SE, and it represents a great philosophical change for Apple, which initially assumed that all you would ever need was what was supplied in its "closed system." Equipped in its base configuration with an internal 20-megabyte hard disk drive and Apple's Standard keyboard, the Mac SE sells for $3698.

It offers reliability, speed, storage, and expandability in the same housing

What's New on the Outside

The Mac SE looks remarkably similar to the Mac Plus except for the platinum color of the housing. The casing size is the same, and it uses the same 9-inch black-and-white screen. The removable battery that powers the real-time clock on old Macs has been replaced on the Mac SE by a lithium battery, which is said to be good for 7 to 10 years, located inside the computer. The modular connector on the front of other Macs used for the keyboard has been replaced on the Mac SE by two Apple Desktop Bus (ADB) ports, which use mini 4-pin connectors, located on the rear. The mouse connection is also gone; the mouse now communicates through an ADB port.

Apple is standardizing peripheral devices throughout the Macintosh product line, which means that you must buy the keyboard separately. Apple currently offers two keyboards: the Apple Standard keyboard ($129), which is similar to the Mac Plus's with a numeric keypad on the right, and the Apple Extended keyboard ($229), which resembles an IBM PC AT keyboard with 15 function keys along the top. There's a large rectangular button at the top of the Standard keyboard that, when pressed, turns on the Mac II's power. This button wasn't intended to provide this capability for the Mac SE, and, to turn this machine on, you still have to hit the power switch on the rear of the computer. Both keyboards have a second ADB port that allows you to daisy-chain other peripherals to the bus. Although the ADB specification allows a maximum of 16 peripherals, signal losses and connector resistances limit you to daisy-chaining three devices.

The Mac SE's mouse has a wedge shape instead of the boxy shape of the former Macintosh mouse; the new shape doesn't require as much wrist elevation as the old one did. This mouse is also used across the Apple product line, including the Apple IIGS and the Mac II. The mouse uses an internal microprocessor to communicate to the ADB ports, and you can connect it to the second ADB port on the rear of the Mac SE; the keyboard is attached to the other port. You can also daisy-chain it through the second ADB port on the keyboard if you prefer.

Another change readily apparent on the Mac SE is the space for an additional internal 800K-byte floppy disk drive or internal hard disk drive. The Mac SE is available with the second floppy disk drive for $2898.

The Old and the New Inside

The Mac SE uses the same 68000 microprocessor used by the Mac and the Mac Plus, running at the same 7.8336 MHz. The Mac SE's RAM is packaged on SIMMs (single in-line memory modules), the same as the Mac Plus's RAM. The Mac SE comes standard with four 256K-byte SIMMs, totaling 1 megabyte of memory. You can mix 1-megabyte SIMMs along with the 256K-byte dynamic RAM (DRAM) SIMMs to aug-

continued

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By changing the memory interleave, a 20 percent gain in microprocessor speed is achieved.

ment the Mac SE's memory according to certain rules. For instance, you cannot mix different densities of RAM—you can mix only pairs of the same density, with the larger-capacity DRAMs located in the sockets closest to the 68000 microprocessor. You can use two SIMMs with 1-megabyte DRAM chips and two SIMMs with 256K-byte DRAM chips to obtain 2.5 megabytes of RAM, or you can use four SIMMs with 1-megabyte DRAM chips to get the maximum 4 megabytes of RAM. Unfortunately, the 1-megabyte DRAMs are expensive; for example, Dove Computer offers a pair of 1-megabyte DRAMs for $999.

The Mac SE accesses its RAM in a totally different way than its predecessors. The Mac's display is memory-mapped, requiring the video circuitry to access memory twice each time it draws a line on the screen in order to know what to draw and thus competing with the microprocessor for memory access. Thus, during the active portion of the screen-scan line, the microprocessor's accesses to RAM are interleaved with the video display's accesses. The "classic" Macintosh approach is to have two microprocessor memory accesses during this active-scan line. The Mac SE, however, sends the video-display hardware one long word (32 bits) in one access, followed by three microprocessor accesses to memory.

By changing the 2-to-2 memory interleave to a 3-to-4 interleave, a 20 percent effective gain in microprocessor speed is achieved. The Dhrystone benchmark confirms this gain. Using the Dhrystone benchmark compiled under Lightspeed C 2.01 with 50,000 iterations and no register variables, the Mac SE performs 877 Dhrystones; the Mac Plus performs 725.

A custom gate array (called the BBU, which stands for "Bob Bailey unit," so named after its designer) takes the place of 19 discrete devices in the "classic" Macs. This gate array also handles the long-word data fetch for the video-display circuitry. The Mac SE's reliability is enhanced by the BBU, since it reduces the number of components and solder joints on the motherboard, thereby reducing the possibility of mechanical or component failures.

The Mac SE does not have an alternate sound buffer, as do the "classic" Macs. The alternate video buffer, used for smooth animation, is retained in the Mac SE's design, however.

Floppy disk drives interface to the Mac SE through a chip known as the Integrated Woz Machine (IWM). This chip is clocked by a C16M signal of 15.6672 MHz and divided down by 2 (resulting in the C8M signal) for 400K-byte and 800K-byte disk accesses. When Apple introduces a 1.6-megabyte floppy disk drive, the Mac SE should be able to use it, since the C16M clock signal is available to the IWM to control such a disk drive at twice the current clock rate. The IWM chip is socketed, allowing it to be replaced by a future disk controller, such as the Integrated Sander Machine (ISM), which will read IBM 3½-inch disks as well as Apple disks.

The Mac SE ROM has increased to 256K bytes from the Mac Plus's 128K bytes. Added features in the Mac SE ROMs include ADB support, a new AppleTalk driver that includes the new Echo and Session AppleTalk protocols, built-in diagnostics, and rewritten SCSI Manager code that supports the new SCSI hardware interrupt on the Mac SE.

The Mac SE's switching power-supply output has been increased from 60 to 100 watts. Apple has added a noisy cylindrical fan to dissipate heat from inside the case. It's a constant-speed fan that makes you wish the Mac SE's cooling could have been augmented in some other way. The fan noise is quite noticeable in a quiet room, but it fades to acceptable background level in an office environment.

The Mac SE's SCSI Interface

As mentioned earlier, the Mac SE comes equipped with a SCSI port. Apple uses a DB-25 external SCSI connector in place of the 50-pin connector defined by the ANSI X3T9.2 standard, but it's identical to the Mac Plus's connector. Unlike the Mac Plus, however, the Mac SE contains an internal standard 50-pin SCSI connector, which is located on the motherboard. This internal connector and the higher-capacity power supply allow you to install a SCSI hard disk inside the Mac SE's housing.

SCSI transfers are handled by an NCR 5380 chip and come in two flavors: blind and nonblind. A blind transfer requires no intervention by the Mac SE's microprocessor, while nonblind reads or writes require that each byte to be transferred must be checked by the microprocessor. Obviously, the blind-transfer method is faster. On the Mac SE, blind transfers are rated at 656K bytes per second, while nonblind transfers are rated at 172K bytes per second, as compared to rates of 312K bytes per second and 142K bytes per second, respectively, for the Mac Plus.

The Mac SE's redesigned SCSI interface now supports the SCSI interrupt request signal from the 5380 chip. This interrupt is used to signal an error condition or to signal that a slow device has completed a request. The BBU can also issue a maskable level-zero interrupt to the 68000 if a SCSI transfer does not occur within 265 milliseconds; this is a bus time-out, possibly due to a device failure. The SCSI Manager can either gracefully abort or retry the operation, depending on how the driver is programmed to respond to the interrupt. For blind reads and writes, a "handshake" technique is implemented in the SCSI interface. This is accomplished by suppressing certain control signals that prevent the microprocessor from accessing the 5380 until it indicates that data has been written or that data is ready to receive. This improves the reliability of this type of high-speed SCSI transfer.

You should note that the SCSI address of the internal drive is 0, so an external SCSI device must have an address different from 0 to be recognized by the Mac SE. Most SCSI peripherals allow you to modify the device address, so this should not be a problem.

Apple sells the Mac SE in a configuration with an internal 20-megabyte SCSI drive that has an 85-ms access time. The Apple internal Hard Disk 20 SCSI drive that came with my review unit proved to be quiet and reliable. An unplanned torture test of this drive occurred during a cross-country flight when I had to ship the computer as regular baggage. Although the Mac SE was subjected to g forces sufficient enough to cause the master power cable to come loose from the motherboard, the drive did not lose any data. I tested the external SCSI port using a Rodime 45-megabyte hard disk drive on the review machine, and I experienced no problems.

The Expansion Port

Probably the hardware change that has caused the most people to consider purchasing a Mac SE is the expansion port that is included on the motherboard. This expansion port brings the unbuffered 68000 signals out to a 96-pin Euro-DIN-type connector that's used by an add-on card.

Various companies are currently designing cards to fit inside the Mac SE. AST Research and Dayna Communications have announced cards that, by working with software and 5¼-inch disk drives, provide the Mac SE with MS-DOS compatibility. This makes the Mac

Macintosh SE

Company
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Size
13½ by 9½ by 11 inches; 17 pounds

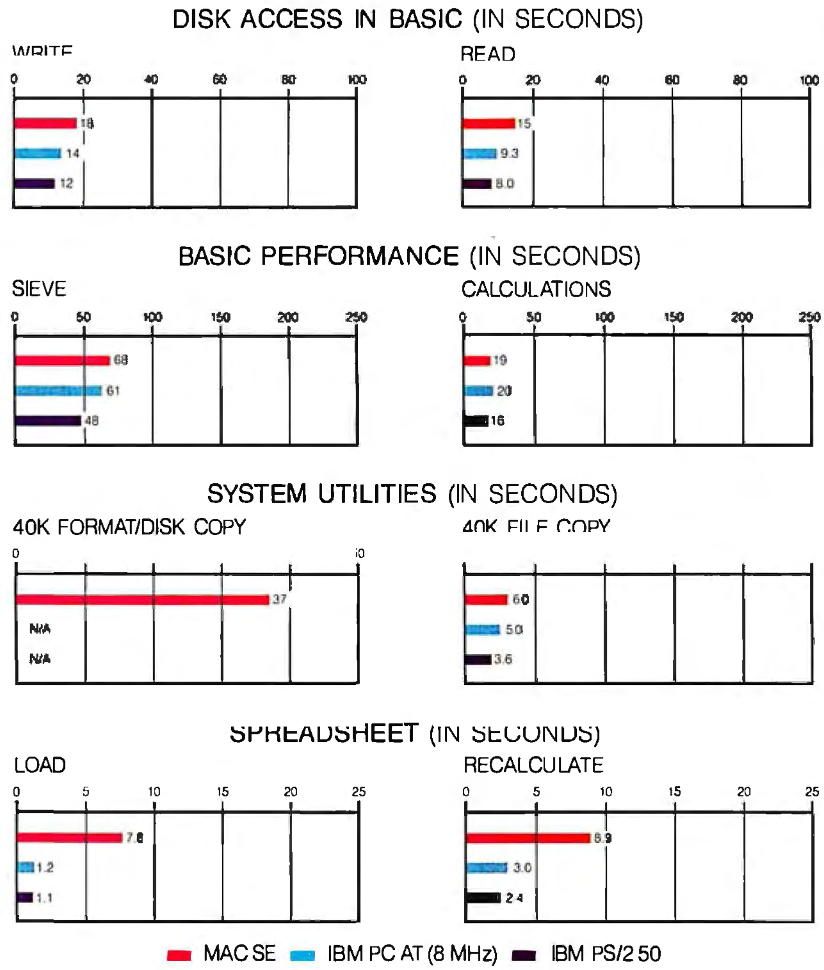
Components
Processor: 32/16-bit 68000 running at 7.8336 MHz
Memory: 1 megabyte of RAM, expandable to 4 megabytes; 256 bytes of user-settable parameter memory; 256K bytes of ROM (168K bytes used for system routines)
Mass storage: One 800K-byte internal 3½-inch floppy disk drive and either a second 800K-byte internal 3½-inch floppy disk drive or one internal 20-megabyte SCSI hard disk drive
Display: 9-inch black-and-white built-in bit-mapped screen; 512 by 342 pixels
Keyboard: Detachable 81-key Standard keyboard with keypad and cursor keys or detachable 105-key Extended keyboard with keypad, cursor, and 15 function keys; both optional
I/O interfaces: Two RS-232C/RS-422C serial ports using mini 8-pin connectors; DB-25 SCSI port; two Apple desktop Bus connectors; external floppy disk drive connector; RCA-type sound connector; one internal 96-pin Euro-DIN connector for expansion boards

Software
System 4.0/Finder 5.4 operating system; system-installer utilities; hard disk backup and repair utilities; font/desk accessory-mover utility

Options
800K-byte external 3½-inch floppy disk drive: $399
Apple Standard keyboard: $129
Apple Extended keyboard: $229

Documentation
Macintosh SE user's manual, 252 pages; *Macintosh System Utilities Guide*, 54 pages

Price
With second internal 800K-byte 3½-inch floppy disk drive and Standard keyboard: $2898
With internal 20-megabyte hard disk drive and Standard keyboard: $3698



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. All tests were performed using System 4.0 and Finder 5.4. MS-BASIC 2.1(b) was used for the System benchmarks. Multiplan 1.1 was used for the Spreadsheet tests, and 400K-byte floppy disks were used for the System Utilities tests. The 40K Format/Disk Copy time is the sum of the 40K File Copy time plus the time required to format a 400K-byte floppy disk (which is 31 seconds).

SE buyable for companies that require computers that must be able to run MS-DOS.

Coprocessor boards are available from Levco, General Computer, and other companies to bypass the 68000 processor completely and run a 16-MHz 68020 (and associated 32-bit-wide memory) in its place. Such accelerator boards make the Mac SE run faster but suffer from software incompatibility with programs that use 68000-specific programming choices. Both Levco and General Computer include a patch for MacWrite 4.5, one of the offending programs. The whole field of Mac SE add-ons is large enough to require several reviews to fully explore it.

System Software

System 4.0 and Finder 5.4 (which will be superseded by versions 4.1 and 5.5 by the time this article sees print) are shipped

continued

The Mac SE performs better than old Macs with memory-intensive programs by 13 to 16 percent.

with the Mac SE. The major visible additions to System 4.0 include: The trash can bulges when you put something into it; the `Get Info` display uses a Monaco 9 font; there's a `Restart` option in addition to `Shut Down` in the Special menu that's useful for hard disk drive owners who want to have their desktop structures safely preserved when they shut down the system; a new "modular" control panel that allows the specification of a start-up device (only on the Mac SE and Mac II); and new or modified icons for Alert boxes that conform more closely to international standards. Apple will attempt to make the system software provide identical features across the entire Macintosh product line with 128K-byte ROMs or more, with the exception of certain 256K-byte-ROM-specific features, like setting the start-up device. You won't have to buy a Mac SE just for these features if you already own a Mac or plan to buy a Mac Plus.

The stated attempt for the Mac SE was to be 100 percent software-compatible with the previous Macs. Software that doesn't use the alternate sound buffer will indeed run on the Mac SE. Only a few exceptions have shown up thus far in commercial software. Red Ryder version 9.4's VT-100 modes don't work with the Mac SE keyboard, although other parts of the program do work. Author Scott Watson has told me that this will be corrected in version 10.0. Videoworks Player 1.0 speeds up both in sound and animation noticeably but still plays.

Concerning compatibility, any program that directly accesses hardware should be considered suspect. Most programs that do this would probably be noncommercial programs distributed in the public domain. Apple has made it quite clear for a long time that directly accessing hardware will cause compatibility problems. However, to correct some problems with the SCSI Manager ROM code on the Mac Plus, hard disk drive companies have had to directly access ROM locations in their SCSI driver programs. These driver programs will not run on the Mac SE because the ROM addresses in the SCSI driver have changed, but hard disk drive companies are scrambling to correct their software and will have Mac SE-compatible drivers available by the time you read this.

Documentation

The documentation that accompanies the Mac SE includes a *Macintosh SE* user's manual that leads the novice through the setup and use of the Mac SE. The manual is refreshingly "noncutesy" in tone and illustrated with what you need to see when you need to see it in the text. Also included is a *Macintosh System Utilities Guide* for the system utilities provided on disk. This document acquaints you with the powerful disk-utility tools, such as Find File and Disk First Aid, and I think the separate manual is a good idea. Some of the most-asked questions from new users in the BIX Macintosh conference concern using the standard utilities and indicate some initial confusion with these tools. Also included is a Guided Tour disk to the Mac SE that is self-playing and demonstrates some of the system's features to those who've never used a computer.

Performance

When you look at the benchmarks for the Mac SE (see figure 1), you see some improvements over the Mac Plus. I ran the standard BYTE benchmarks on a Mac Plus and a Mac Plus-caliber machine (MaxPlus) equipped with hard disk drives. As you can see, the Mac SE performs better than the other machines (by 13 to 16 percent) with memory-intensive programs in the Sieve and Calculations benchmarks. This corresponds with the Mac SE's increased memory access. The Mac SE also did slightly better (by about 7 percent) with file I/O to the hard disk in the Write and Read benchmarks (interestingly, the MaxPlus's DataFrame 20 drive did slightly worse than the Mac Plus's Hard Disk 20 drive in the Write bench-

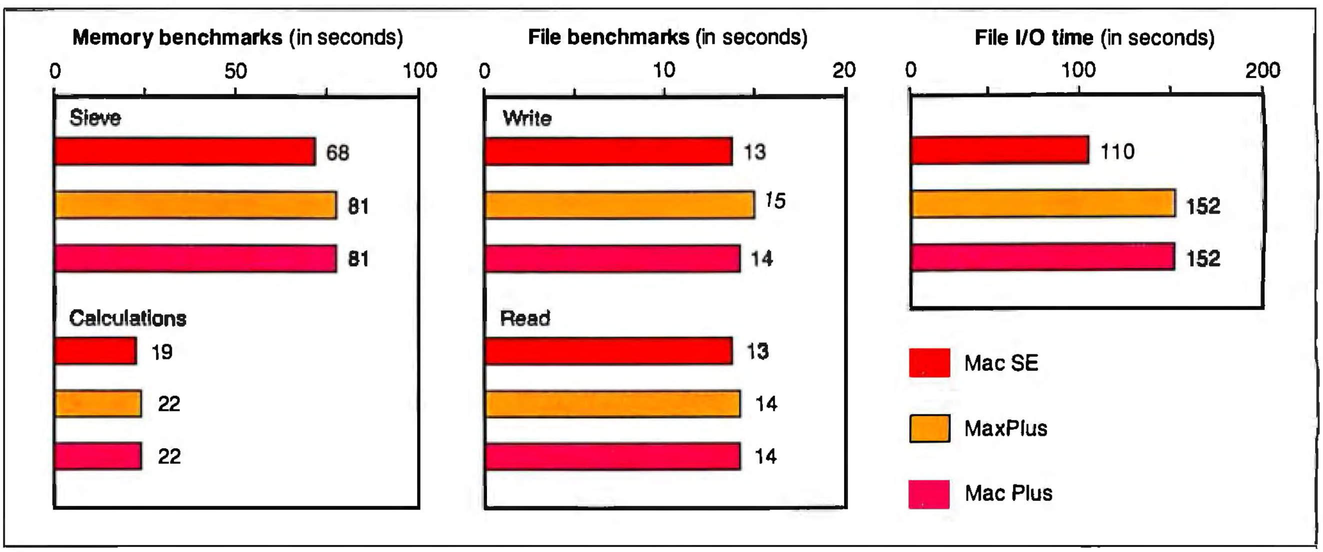


Figure 1: *A comparison of the Mac SE against a Mac Plus and a Mac Plus-caliber machine. "MaxPlus" is a 512K-byte Macintosh with a 128K-byte ROM upgrade, MacMemory's 2-megabyte RAM expansion, and SuperMac Technology's SCSI port upgrade and DataFrame 20 20-megabyte SCSI hard disk drive. The Mac Plus tested was equipped with an Apple Hard Disk 20 20-megabyte hard disk drive connected to the external floppy disk port. The Mac SE used System 4.0 and Finder 5.4, while the MaxPlus unit and Mac Plus used System 3.2 and Finder 5.3. All machines used the MS-BASIC 2.1(b) interpreter for the Memory and File tests. The File I/O benchmark is a C program that reads and writes to a 65,000-byte disk file and was compiled with Think Technologies' Lightspeed C 2.01 compiler.*

mark). The BYTE Fileio benchmark, in which a compiled program writes a 65,000-byte file to disk, showed a substantial improvement in performance (27 percent). While individually these tests indicate a small improvement in performance, remember that, as a whole, both memory processing and faster file I/O combine to boost the overall performance of the Mac SE. For additional benchmark results, see the graph on page 203.

Should You Own One?
When trying to decide whether to buy a Mac SE or a Mac II, consider that the Mac SE will cost less, will not be as expandable as the Mac II (one expansion slot versus six NuBus slots), and will have black-and-white output, but the machine is transportable. Some 68020 accelerator cards, such as General Computer's HyperCharger ($1699) and Levco's Prodigy SE ($1499), are available if you must have faster performance. Such cards obviously add to the price of the Mac SE, but these prices are already dropping as the market for Mac SE hardware add-ins matures and the competition intensifies. In my mind, the transportability of the Mac SE is the overriding factor in this decision: I use one computer in many places. The convenience of having all the Mac SE's computing power and the internal hard disk drive in the standard Macintosh footprint makes my computing easier and more productive.

The problem is thornier for users who already own Macs, since Apple doesn't offer an upgrade path to the Mac SE as it did for 128K/512K-byte Mac owners to a Mac Plus configuration. Is the improved performance worth the trouble of selling the old machine and then buying the Mac SE? I'm impressed with the snappier response of the Mac SE; I sure don't want to give the review unit back. However, I can't justify the additional expense of the machine. The deciding factor will be if you want to expand your Mac in the future; the Mac SE's internal slot makes that easy. For those who don't need the slot, there's still hope: A number of companies, including MacMemory, Novy Systems, and Spectra Micro Development, offer 68020 accelerator upgrades for the Mac Plus.

The Mac SE is a refinement of the original concepts that were the hallmark of the original Macintosh. It is a transportable computer with an easy-to-use operating system that now includes easily expanded hardware. The machine can fulfill the general-purpose computing needs of both individuals and businesses at a reasonable price. I was impressed by the machine's hardware, and I ran my favorite software on it without problems. ■

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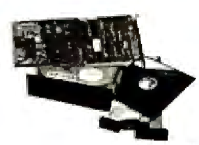

• 20MB Seagate ST-225 w/controller (65 ms)	$350
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Two High-Performance PC AT Compatibles

John Unger

These machines offer speed and PC AT compatibility at reasonable prices

The ITT XTRA/286 ATW (right) and the AST Premium/286 (left), two high-performance IBM PC AT clones, feature PC AT compatibility and 10-MHz 80286 microprocessors that make their performance significantly faster than that of the PC AT and similar clones that have 8-MHz clock rates. They are both big, hefty microcomputers with large internal expansion capabilities and generous power supplies.

The basic versions of the XTRA/286 ATW (which stands for Advance Technology Workstation) and the Premium/286 include a 1.2-megabyte floppy disk drive (but no hard disk drive) and an EGA-compatible four-mode display adapter for a price of about $2500. In these configurations, the XTRA/286 ATW comes with 640K bytes of RAM, and the Premium/286 has 1 megabyte of memory. At the high end of the spectrum is the XTRA/286 ATW Model III ($4299), which has a 30-megabyte hard disk drive and 640K bytes of memory, and the comparable Premium/286 Model 140 ($3495), which has a 40-megabyte hard disk drive and 1 megabyte of RAM. These high-end machines were the ones that I tested for this review. Each review unit had an optional enhanced graphics monitor to match its standard multipurpose display adapter; the XTRA/286 ATW's costs $749, and the Premium/286's costs $695. Look for bargains on the Premium/286; one advertiser in the June BYTE was selling the Model 140 for $2449.

The Premium/286 (left) and XTRA/286 (right).

A Lot in Common

Although both machines use a 10-MHz 80286 microprocessor, the XTRA/286 ATW's can operate at either 10 MHz (with one wait state) or 6 MHz (with zero or one wait state), and the Premium/286's provides three clock rates: 6, 8, and 10 MHz, all running with zero wait states. You can toggle the clock rate on either system at any time by using a simple keystroke combination, and a convenient LED display on the front panel of the Premium/286 tells you what the current clock rate is. Both machines have a socket for installing an optional 8-MHz 80287 math coprocessor chip.

The internal layouts of the two computers are similar and follow the general PC AT configuration, with space for a full-height hard disk drive and three half-height storage devices. They both have the top slot occupied by a 1.2-megabyte floppy disk drive. The XTRA/286 ATW's 220-watt and the Premium/286's 195-watt power supplies are located in the rear of the two computers behind the disk drives.

The XTRA/286 ATW has eight full-length expansion slots; two of these are IBM PC-compatible 8-bit slots, and the remaining six are PC AT-compatible 16-bit slots. The display adapter card occupies one of the 8-bit slots, and the hard disk controller fills a 16-bit slot; the floppy disk controller is part of the motherboard.

The Premium/286 has seven expansion slots: one 8-bit IBM PC-compatible slot, four PC AT-type 16-bit slots, and two special slots that are 16-bit PC AT-compatible, but which also include an additional connector for AST Research's "FASTslot" expansion cards (which are described below). The display adapter occupies the lone 8-bit slot, the system's RAM is on a card in one of the FASTslots, and a single controller for the hard and floppy disk drives takes up one of the conventional 16-bit slots.

Both microcomputers make ample use of custom VLSI chips from Chips and Technologies to reduce the number of ICs on the motherboard and video adapters. The Premium/286 also uses its own custom-designed VLSI I/O port controller chip. The ROM BIOS used by both computers is from Phoenix Technologies; this BIOS is well known for its high degree of compatibility with IBM's BIOS.

Both systems have keys that lock up the keyboard to prevent someone from mess-

continued

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ing around with your unattended computer. The Premium/286 includes a convenient front-panel hardware-reset switch, a feature that is lacking on the XTRA/286 ATW.

And a Few Differences . . .

You might think from the preceding paragraphs that not much separates these two machines in the way of hardware. However, they do have some significant differences.

The Premium/286's hardware is clearly designed to optimize performance. All the key components, including the microprocessor, memory, memory access, system bus, access to system peripherals, and the peripherals themselves, are integrated for maximum performance.

As mentioned above, the Premium/286's 1 megabyte of 100-nanosecond RAM resides on a FASTRAM expansion board plugged into one of the 16-bit FASTslot expansion slots, rather than on the motherboard as is common with most PC AT compatibles. You can populate each FASTRAM card with 2 megabytes of memory using 100-ns 256K- by 1-bit chips. With two fully populated cards installed, you can have 4 megabytes of zero-wait-state memory in the computer. Be forewarned that 100-ns RAM chips are more expensive and not as easily obtained as their slower brethren; a 2-megabyte FASTRAM card costs $1495.

The FASTslot gives the Premium/286's RAM direct access to the 80286. Special arbitration-logic signals located on the FASTslot bus allow the microprocessor to perform zero-wait-state memory access at any of its clock rates. Memory-management logic on the RAM card checks to see if the address requested by the microprocessor resides on that card at the same time that the motherboard logic checks the system bus. If the address is on the FASTRAM card, it sends a signal to the motherboard to suspend system-bus access; if the motherboard logic receives no signal, the memory access proceeds as normal.

For increased compatibility with PC AT-compatible add-on cards, the motherboard automatically inserts one wait state on the system bus when operating at 6 MHz or 8 MHz, and it inserts two wait states when running at 10 MHz.

The XTRA/286 ATW has a more traditional memory setup, and you can increase the 640K bytes of standard 120-ns RAM to 1 megabyte with 256K- by 1-bit chips on the motherboard without having to add an expansion card.

Megabytes of Mass Storage

Both systems I reviewed were configured with one 1.2-megabyte floppy disk drive

ITT XTRA/286 ATW

Company
ITT Information Systems
2350 Qume Dr.
San Jose, CA 95131
(408) 945-8950

Size
21¼ by 17 by 6½ inches;
41 pounds

Components
Processor: 16-bit, 10-MHz 80286 with one wait state, switchable to 6 MHz with either zero or one wait state; optional 80287 math coprocessor
Memory: 640K bytes of 120-ns RAM, expandable to 1 megabyte on system board; system diagnostics in ROM
Mass storage: One 1.2-megabyte floppy disk drive (Model I) plus one 30-megabyte hard disk drive (Model III)
Display: ITT XTRA EGA—includes all IBM monochrome, CGA, and EGA text and graphics modes (640 by 350 monochrome, 320 by 200 color, and 640 by 200 color), plus Hercules 720 by 348 monochrome graphics; monitor optional
Keyboard: 84 keys; 10 function keys; separate keypad/cursor keys; LED indicators for Caps Lock, Num Lock, and Scroll Lock keys
I/O interfaces: Eight full-length slots: six 16-bit PC AT-compatible, two 8-bit PC-compatible; RS-232C port with 9-pin D-shell male connector; Centronics-compatible parallel printer port with 25-pin D-shell female connector; standard RGB connector for color or enhanced monitors; standard jack for composite monochrome monitor

Software
MS-DOS 3.1 operating system with GW-BASIC; ITT system utilities and diagnostics FXP disk-caching; ASYCOM communications program

Options
Monochrome monitor: $189
CGA monitor: $545
EGA monitor: $749

Documentation
User's Guide for the ITT XTRA/286 ATW, 153 pages; *Getting Started with MS-DOS*, 123 pages; *MS-DOS Command Reference*, 249 pages; *Quick Reference*, 29 pages

Price
Model I (with 640K bytes of RAM): $2499
Model III (with 640K bytes of RAM and one 30-megabyte hard disk drive): $4299

AST Premium/286

Company
AST Research Inc.
2121 Alton Ave.
Irvine, CA 92714
(714) 863-1333

Size
19¼ by 16½ by 6½ inches;
40 pounds

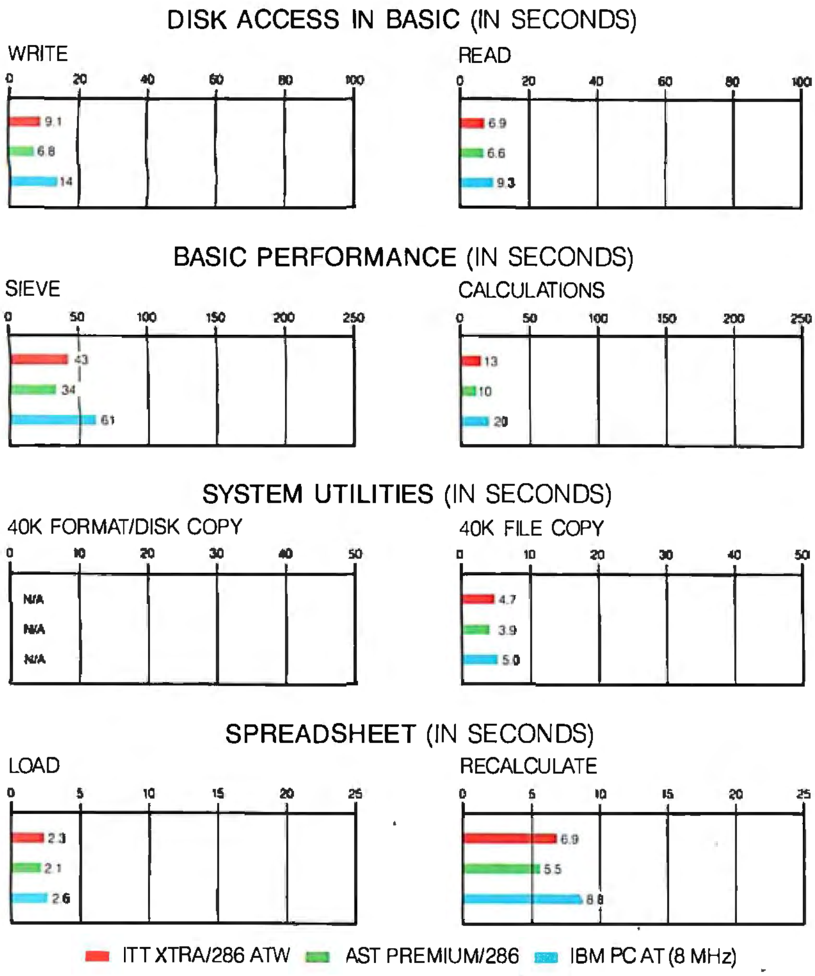
Components
Processor: 16-bit 80286, switchable to either 10, 8, or 6 MHz with zero wait states; optional 8-MHz 80287 math coprocessor
Memory: 512K bytes (Model 80) or 1 megabyte (all other models)
Mass storage: One 1.2-megabyte floppy disk drive (all models); hard disk drives optional
Display: No display adapter on Model 80; AST-3G Plus display adapter with CGA, EGA, and Hercules emulation on all other models; 720 by 350 or 640 by 200 resolution (monochrome); 640 by 350 or 640 by 200 resolution (color); monitor optional
Keyboard: 101 keys; 12 function keys; separate editing keys and keypad; LED indicators for Caps Lock, Num Lock, and Scroll Lock keys
I/O interfaces: Seven full-length slots: One 8-bit PC-compatible, four 16-bit PC AT-compatible, two 16-bit PC AT-compatible; RS-232C port; Centronics-compatible parallel printer port; AST-3G Plus board has standard RGB connector for color or enhanced monitors and standard jacks for composite monochrome monitor.

Software
MS-DOS 3.1 operating system; GW-BASIC; AST software utilities and system diagnostics

Options
360K-byte floppy disk drive: $155
Additional 1.2-megabyte floppy disk drive: $195
Monochrome monitor: $195
EGA monitor: $695
FASTRAM 2-megabyte expansion card: $1495

Documentation
User's Reference, 214 pages; *Operating System* manual, 216 pages; *BASIC* manual, 281 pages; *Supplement* manual, 226 pages

Price
Model 80 (512K RAM): $1995
Model 90 (1 megabyte RAM): $2495
Model 120 (1 megabyte RAM, 20-megabyte hard disk drive): $2995
Model 140 (1 megabyte RAM, 40-megabyte hard disk drive): $3495
Model 170 (1 megabyte RAM, 70-megabyte hard disk drive): $3995



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 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 graph shows 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 from a floppy to a hard disk using the system utilities. The Spreadsheet graph shows 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. Tests on the ITT XTRA/286 ATW and the AST Premium/286 were done at 10 MHz, using GW-BASIC 3.11 and MS-DOS 3.1. Tests on the IBM PC AT were done using BASICA and PC-DOS 3.2. Microsoft Multiplan 1.06 was used for the spreadsheet benchmarks.

and one hard disk drive. The floppy disk drive in the XTRA/286 ATW that I reviewed was made by Panasonic; the Premium/286 had a TEAC drive. Both of these drives can format and write to standard double-sided, double-density 360K-byte disks, as well as to high-density 1.2-megabyte media. I had no problems reading the 360K-byte disks written with either of these high-density drives in the standard 360K-byte disk drives on other computers, such as an IBM PC AT and an AT&T 6300 Plus.

The hard disk drive in the XTRA/286 ATW that I reviewed was a 30-megabyte Seagate ST4038, which has an average access time of 33 milliseconds according to the CORE.EXE hard disk performance test. In comparison, the 40-megabyte Micropolis hard disk drive in the Premium/286 showed an average access time of 22 ms in the same test. Both hard disk drives operated quietly and flawlessly during the course of the review.

To compensate for the somewhat slower hard disk drive, ITT includes a proprietary disk-caching utility called FXP (which will work only with hard disks) with the XTRA/286 ATW. The benefits of this program are most noticeable when reading and loading data from the disk; FXP reduced the Disk Access in BASIC Read benchmark time for the XTRA/286 ATW from 6.9 to 5.7 seconds, and it decreased the time required to load files in the 100-row by 25-column Spreadsheet benchmark by about one-half, from 2.3 to 1.2 seconds.

A useful feature of the XTRA/286 ATW's hardware/software design is that the system diagnostic programs, which test the disk drives, keyboard, and so on, are in ROM, so you can access them at any time using a keystroke combination. This is much more convenient than having to hunt around for a diagnostics disk that you misplaced a few months earlier.

Ports

Each computer has an RS-232C serial port and a Centronics-compatible parallel port. On the Premium/286, these two ports are part of the motherboard. The serial port's connector is a 25-pin D-shell.

The XTRA/286 ATW uses ICs on its video board to drive its serial and parallel ports. Two ribbon cables carry the signals from the video board to the connectors for the ports, which are mounted on the adjacent slot. However, the ribbon cables and the connectors that mate them to the video board protrude into the area occupied by the adjacent slot and make it impossible to install a 16-bit board in that slot. In fact, I damaged a connector on

continued

one of the ribbon cables while attempting to install an AST Advantage! board. The XTRA/286 ATW's serial connector is a 9-pin D-shell like that used on the IBM PC AT.

Displaying Their Colors

Versatile display adapters are standard on both of these computers. They offer compatibility with four standard display modes: IBM's Enhanced Graphics Adapter (EGA), Color Graphics Adapter (CGA), and Monochrome Display Adapter (MDA), and the Hercules monochrome graphics card. I could find no markings on the XTRA/286 ATW's board, which, according to the company, is its own. The video board in the Premium/286 is the AST-3G Plus board. The optional EGA monitors that come with each computer can display color graphics software that is compatible with either a CGA or an EGA.

The two systems differ in how they handle CGA emulation with the EGA adapter and monitor. With the Premium/286's AST-3G Plus board, you need only flip a toggle switch on the card to run CGA graphics programs. With the ITT display adapter, you have to change the settings on a DIP switch on the card. However, this switch is recessed, and you must physically get behind the computer and manipulate the tiny switches with a small screwdriver or similar tool.

Another difference between the displays is that the Premium/286 continues to display text characters in an 8- by 14-pixel cell while in CGA-emulation mode, but the XTRA/286 ATW reverts to the standard, harder-to-read, 8- by 8-pixel cell of the CGA mode when in emulation mode. AST supplies a utility program called EMUL with the Premium/286 that allows you to change back and forth between EGA- and CGA-emulation modes strictly in software.

Both monitors performed well and had clear, steady images. I liked the XTRA/286 ATW's monitor slightly better because its characters seemed sharper and less fuzzy than those on the Premium/286's monitor. On the Premium/286's monitor, lighter colors appeared to be somewhat washed-out compared to those on the XTRA/286 ATW's monitor.

Both monitors have convenient front-panel controls for brightness and contrast and include base units that enable you to swivel and tilt the monitors. The base unit on the Premium/286's monitor has a larger range of movement and is therefore easier to use.

Keyboards: Old Versus New

The ITT XTRA/286 ATW's keyboard is patterned after the original IBM PC AT's, which I think is the best layout that IBM has come up with. This configuration has 10 function keys in two columns on the left side of the keyboard, a large-size Enter key, and a combined numeric keypad/editing keys cluster on the right end of the keyboard.

The Premium/286's keyboard is significantly larger than the XTRA/286 ATW's and has a layout like that of IBM's 101-key enhanced keyboard: 12 function keys across the top above the number keys; a small Enter key; relocated Alt, Esc, and Ctrl keys; and a cluster of independent editing keys between the main keyboard layout and the numeric keypad.

Because I use WordPerfect, a program that involves heavy use of the function keys, and because I have grown used to the basic key layout on my own machines (an AT&T 6300 and an old IBM PC AT), I found the XTRA/286 ATW's keyboard more to my liking than the Premium/286's. The Ctrl key is convenient to the function keys, and you can enter the combination of a function key and the Ctrl, Shift, or Alt key with one hand to execute WordPerfect commands. On the other hand, spreadsheet users may find the Premium/286 keyboard's layout more to their liking because they can input numbers with the keypad while still having the separate editing keys to move around the spreadsheet.

The XTRA/286 ATW's keys provide just about the right amount of tactile feedback for my taste. I found it easy to type rapidly and accurately on it. The keys on the Premium/286's keyboard feel mushier and do not have the same crisp break when pushed. Even though the *F* and *J* keys have slightly dished tops, I found it hard to return to the home position after moving up to the top of the keyboard to hit a function key. Both keyboards have cords that are long enough to enable you to have the main system unit on the floor beside your work space and keep just the monitor and keyboard on the desktop.

Performance and Compatibility

One clear conclusion can be drawn from looking at the benchmark tests: Both of these computers perform extremely well. I found that the XTRA/286 ATW performing at 10 MHz with one wait state was almost equivalent to the Premium/286 running at 8 MHz with zero wait states. The Premium/286 is the hands-down winner when running at 10 MHz, and both machines are significantly faster than an 8-MHz IBM PC AT. I have also reviewed the Compaq Portable III, a PC AT clone that runs at 12 MHz with one wait state; the Premium/286 running at 10 MHz with zero wait states shows a slight (about 10 percent) increase in performance over the 12-MHz Compaq Portable III. [Editor's note: *For more information, see the review entitled "Compaq's New Carryon" in the May BYTE.*]

When I was using the XTRA/286 ATW and the Premium/286, it was difficult to detect any great differences in how fast they seemed to operate while running standard software, such as word processors. In an informal test of scrolling speed at 10 MHz, the XTRA/286 ATW displayed the file used in the BYTE 40K File Copy test to the screen (using the `type` command) in 37 seconds; the Premium/286 took 57 seconds to display the same file. See the complete benchmark results on page 209.

You sometimes pay a penalty for this type of performance, however. In this case, the penalty is a compatibility problem with the Intel Above Board/AT memory-expansion card. I could set up the card and boot the XTRA/286 ATW only with Intel's Expanded Memory Manager program while the computer was running at 6 MHz. Even then, I got an error message telling me that part of the expanded memory wasn't working correctly, although the system had actually tested and recognized the entire 1 megabyte of memory on the Above Board/AT.

I could not run the Intel setup software on the Premium/286 at 6 MHz; the installation program could not find the Above Board/AT's memory, and the computer completely froze up and had to be rebooted with the reset switch. My Above Board/AT is configured with 150-ns RAM chips, and it functions perfectly in a 6-MHz IBM PC AT. I had no problems whatsoever using AST's RAMpage! or Advantage! memory-expansion boards in either computer. Both of these boards use 120-ns RAM chips.

Both computers ran my entire collection of IBM software with flying colors. I had to switch the display-adapter cards to their CGA modes to run Starflight, Flight Simulator, and Jet. Everything else I tried ran fine in EGA mode, including WordPerfect, Reflex, DESQview, SideKick, and Best Programs' PC/TaxCut program.

Documentation, Software, and Setup

Both computers come with complete, well-written documentation. The XTRA/286 ATW manuals are simple 8½- by 6-inch spiral-bound books. The reference most obviously lacking from these manuals is any kind of description of GW-BASIC, which ITT furnishes with the computer's operating system software. However, ITT includes a card with the computer that you can send in to receive a free copy of the GW-BASIC manual.

My review unit also came with a photocopied prepublication version of the *XTRA/286 ATW Technical Reference* manual, which includes information on the MS-DOS functions, how to access them in assembly language, details on programming the various modes on the video card, and so on. If you are planning to use this computer in any sophisticated configurations, such as a network file server or in an application that includes hardware expansion, I would strongly suggest obtaining this manual.

The documents for the Premium/286 come in four 9- by 8-inch three-ring binders that fit inside stylish slipcases, which make it easy to add addenda and other information. One of these documents, the *BASIC* manual, is a complete GW-BASIC manual from Microsoft.

Both computers use MS-DOS 3.1 as an operating system. The operating system software has been enhanced by ITT and AST with additional utility programs, such as the aforementioned FXP and diagnostics.

Reputable Service, Real Warranties

A 12-month warranty is standard for both machines; service is from the authorized dealer who sold you the computer or from the factory, but you have to pay for your own shipping costs. AST has been a well-respected manufacturer of expansion cards for many years and has a fine reputation for the quality of its hardware and service; the Premium/286 is the first complete microcomputer system that the company has manufactured.

When I contacted AST's technical-support staff concerning the problems that I had with the Above Board/AT, they were helpful and gave me some advice that they had received from one of their field technicians. However, I still could not get the card to work properly in the Premium/286.

The ITT XTRA/286 ATW is the third ITT microcomputer that I have reviewed for BYTE. [Editor's note: *See the April 1985 BYTE and the July 1986 BYTE for reviews of the ITT XTRA and the ITT XTRA XP, respectively.*] I was impressed with the quality of the first two ITT machines, and this one backs up my original opinions. Certainly the built-in ROM diagnostics minimize service problems by helping you to easily pinpoint any problems if they should arise.

The ITT XTRA/286 ATW and the AST Premium/286 are both good, solid PC AT compatibles that easily outperform most of their competitors by a clear margin. They come from reliable manufacturers of PC hardware, and the only problems I had with them were trying to install the Above Board/AT on both machines and trying to mount a 16-bit expansion card next to the XTRA/286 ATW's video display board.

The AST Premium/286 has an indisputable edge in performance over the ITT XTRA/286 ATW. In the configuration that I reviewed, the Premium/286 also gives more computing power for the dollar, especially when compared to a similarly equipped IBM PC AT, which costs over $5000. I would give the overall edge in quality of construction to the XTRA/286 ATW; for example, the case has more internal bracing and appears to be made from a thicker gauge of steel. I would not hesitate to recommend either machine to anyone who needs a high-performance, state-of-the-art 80286 microcomputer with a large expansion capacity. Only the few 80286-based computers that are using clock rates of 12 MHz or computers that have 80386 microprocessors will outperform these two, and then only if they are running with zero wait states like the AST Premium/286. ■

80386 Accelerator Boards

Donald Evan Crabb

These two boards give 80286 PC AT compatibles 80386 power

Intel's Inboard 386 and American Computer and Peripheral's 386 Turbo are expansion cards that contain 80386-16 microprocessors. Both cards plug into an expansion slot on the IBM PC AT and compatibles and connect by cable to the 80286 socket, from which you must remove your system's existing microprocessor chip. By executing instructions on a 16-MHz 80386, these boards can improve the overall performance of a PC AT by 2 to 2½ times. They also provide for concurrent processing, hardware-based multitasking, and multiple 8086 virtual-machine processes for operating systems designed to support them, such as IBM's OS/2 and Digital Research's Concurrent PC DOS.

At $1995 or $2495 for the Inboard 386 (depending on the configuration you choose) and $1695 for the 386 Turbo, these accelerator boards are rather expensive, but they provide significantly increased performance while maintaining software compatibility with PC-DOS-based applications.

American Computer and Peripheral's 386 Turbo (top) and Intel's Inboard 386 (bottom).

What You'll Need

The minimum system configuration required to run the Inboard 386 is an IBM PC AT (either 6 MHz or 8 MHz), Tandy 3000, or Compaq Deskpro 286 (but not the Compaq Portable, Portable II, or Portable III). Intel says that it is currently testing other PC AT clones and that installation kits and modifications to the board's utility software will eventually be available to make the Inboard 386 work with other clones. The board requires at least 512K bytes of RAM on the PC AT's motherboard.

To run the 386 Turbo, according to the installation manual, you'll need an American 286-A, IBM PC AT (either 6 MHz or 8 MHz), or any other "100 percent PC AT-compatible clone," although the manual does not list the clones that American Computer and Peripheral has tested and validated. According to American, the 386 Turbo has no minimum motherboard memory (i.e., conventional DOS memory) requirement because of its on-board memory, which I'll discuss later. Also, according to the company, the board won't run on zero-wait-state machines.

These boards are full-size PC AT-compatible cards intended for installation in a 16-bit PC AT slot near the existing 80286 socket on the PC AT's motherboard (slot 4 or 5 for the Inboard 386, and slot 6 for the 386 Turbo). Both units that I reviewed came with a 16-MHz Intel 80386-16 microprocessor, 1 megabyte of fast RAM (using 120-nanosecond 256K- by 1-bit chips—standard on the 386 Turbo and optional on the Inboard 386), a special adapter/connector that plugs into the 80286 socket on the PC AT's motherboard, and a cable that connects the adapter to the accelerator board.

I tested the boards on an IBM PC AT running at 8 MHz with a 1.2-megabyte floppy disk drive, a 30-megabyte hard disk drive, and 1 megabyte of RAM. I used PC-DOS 3.2 for all the benchmark and usage tests.

Installer Beware

Both accelerator boards were tediously difficult to install and configure. On page 1, the Inboard 386 installation manual flatly tells you to "Let your dealer install the Inboard 386." I could hardly agree more. I just wish that American would make the same statement in the 386 Turbo's manual. If you've never done board installation in your PC AT, these two boards are *not* the ones to start learning with.

The first problem I encountered was removing the existing 80286 chip. American does not provide any sort of chip puller with the 386 Turbo, although the manual suggests that you could use "an unused bracket from the back panel" as a wedge to work the 80286 free. After several minutes of trying this, I realized that

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I would bend or break a pin on the 80286 chip before I had finished the job.

Fortunately, the Inboard 386 installation kit included a couple of different chip pullers to help with this task: a simple lever (labeled an 80287 chip puller) and a fancier screw-lifting unit that works like a corkscrew to lift the 80286 out by applying equal pressure around its periphery. Even with these aids, removing the recalcitrant chip took a couple of hours of determined, though gentle, effort.

Each company provides an adapter to snap into the empty 80286 socket. The adapter provided with the 386 Turbo is a small printed circuit board attached to two short ribbon cables that lead back to the accelerator card. The Inboard 386 comes with a longer and more fragile flat tape cable with pin grid array (PGA) connectors on either end to make the connection from the 80286 socket to the accelerator board.

Once I had determined how I would run the cables under existing boards (a process that should not be taken lightly, since the cable shouldn't run up against the electrical contacts of any other boards), attaching the adapter/connector for each of the boards was fairly easy, although the fragility of the Inboard 386's cable worried me. The manual explicitly warns against creasing the cable and breaking traces, so I handled it gingerly. In the end, though, it caused no problems. The Inboard 386 also comes with a replacement motherboard crystal to increase your PC AT's base cycle rate from 6 MHz to 8 MHz, since the board will not function properly with a 6-MHz motherboard.

The Inboard 386 does not work with an 80287 math coprocessor installed, so I removed the existing 80287 from my test machine and replaced it with Intel's optional 80287-10 coprocessor module ($495), which plugs into a socket on the Inboard 386. Installing the 80287-10 was a snap, since removing the existing rectangular 80287 with its L-shaped pins took only a few minutes. I suspect that the 80287 may have been put in the computer by hand, whereas the motherboard-mounted 80286 was probably put in by machine.

According to the installation manual, the 386 Turbo will work with most current 80287 processors, and, indeed, it worked with the original one installed in my PC AT. The manual claims that early "substandard" 80287 chips are a problem, although I could not verify this assertion. If you do not have an 80287 installed in your PC AT, you must install a special adapter, which is provided with the board, in the 80287 socket so that the system will function correctly. When I tested the 386 Turbo without the adapter in the empty 80287 socket, the PC AT froze up and would not operate.

Configuration Confusion

Configuring the two boards was also a tedious task that required a certain amount of trial and error. Both boards use DIP switches and jumpers to set various hardware options and memory configurations. Each also comes with a set of utility programs that let you establish the faster clock rate of the 80386 upon startup, change the processor speed without rebooting, and enable and disable different memory schemes. American includes utilities with the 386 Turbo that let you use different non-IBM EGA boards and enable the PC AT to execute BIOS, DOS, and video instructions from the board's 1 megabyte of cache memory to further improve speed. The Inboard 386 comes with a utility program that verifies that the 80287-10 coprocessor module is correctly installed, as well as a program that makes up for some undocumented features in the 80286 that can be used by some software and are missing from the 80386.

The software-configuration process took several hours for the 386 Turbo, but I was able to configure the Inboard 386 in about 45 minutes, partly due to its configuration scheme and partly because of its helpful manual.

The installation and configuration manuals provided with these two boards could hardly be more different. The Inboard 386's manual is clear, easy to read, nicely designed and printed, well referenced, and detailed in most of its explanations, such as exactly what each of the jumper and DIP switches were for, how to set them, and so on. The 386 Turbo's manual is far too brief, contains little detail, includes some worthless line drawings, and displays poor production quality. In short, the manual was a real disappointment. A $1995 product deserves a much more complete and well-executed manual.

Intel's technical support is also better than American's; the technicians actually returned my calls. When I called American and identified myself merely as a user, the technical staff was usually not available and returned my calls only once out of three or four times.

Memories, Memories

The design of the Inboard 386 lets you add a megabyte of fast 256K-bit memory chips and a piggyback board that holds an additional 2 megabytes of RAM. You can use this memory in place of some of the PC AT's existing memory, and you can configure it to run under the Lotus/Intel/ Microsoft Expanded Memory Specifica-

Table 1: *The Disk Write and Disk Read tests show how long it takes to write and then read a 64K-byte sequential text file to a 30-megabyte hard disk. (For the program listings, see BYTE's* Inside the IBM PCs, *Fall 1985, page 195.) The Sieve test shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations test shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The 40K File Copy test shows how long it takes to copy a 40K-byte file using the system utilities. The Spreadsheet Load and Recalculate tests 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. Tests were performed on the Inboard 386 and the 386 Turbo installed in an 8-MHz IBM PC AT and were compared with the results for a standard 8-MHz PC AT and results for a Compaq Deskpro 386. All times are in seconds.*

Product	Disk Write	Disk Read	Sieve	Calculations	40K File Copy	Spreadsheet Load	Spreadsheet Recalculate
Inboard 386	6.97	4.44	29.62	10.02	2.80	1.54	4.02
386 Turbo	5.68	4.05	24.92	8.28	2.25	1.34	3.51
IBM PC AT (8 MHz)	14.0	9.3	61	20	5.0	2.6	8.8
Compaq Deskpro 386	5.14	4.82	22.76	6.89	1.01	2.07	4.1

tion (EMS) or as 80386 extended memory (for special RAM cache use now and as directly addressable 80386 memory when operating systems that support this mode become available).

The 386 Turbo is not as complicated as the Inboard 386, since it does not accommodate piggyback boards for math coprocessors or for additional memory. Its memory-configuration capability is also simpler than that of the Inboard 386, since its entire megabyte of memory functions as a processor cache for the 80386 and does not support EMS or 80386 extended memory (or any utility software that could support these memory schemes).

A Compatible Couple

To test the compatibility of the Inboard 386 and the 386 Turbo, I tried every DOS-compatible application I could lay my hands on, including integrated packages, project managers, database managers, financial software, word processors, programming languages, CAD and statistics packages, and a number of shareware utilities, games, and communications programs. All worked fine at 16 MHz except for some of the games, which often have timing loops that are processor-sensitive. For example, version 1.1 of Microsoft's Flight Simulator wouldn't work at 16 MHz, although version 2.1 worked fine. The only other programs that wouldn't work properly with the boards running at 16 MHz (but did work at the slower speed) were Crosstalk XVI version 1.1 (a communications package) and some shareware disk-utility and disk-copying programs, including Exactcalc, ProCopy, Speedcopy, and ProForm.

Overall, the Inboard 386 and the 386 Turbo ran existing DOS-compatible software equally well. Unless you really work at causing compatibility problems, once you have installed these boards and set up the proper utility programs to support them, you can practically forget you are using them.

Benchmarks

I ran the standard BYTE benchmarks with the Inboard 386 and 386 Turbo installed in an 8-MHz PC AT configured with 1 megabyte of RAM, a 30-megabyte hard disk drive, an EGA card and extended color monitor, a 1.2-megabyte floppy disk drive, PC-DOS 3.2, BASICA 1.1, and Multiplan 1.06. The results are shown in table 1, which also contains benchmark figures for a standard 8-MHz PC AT and a Compaq Deskpro 386 running DOS 3.1. To obtain the best possible performance from each machine, I set the Inboard 386's 1 megabyte of memory to provide a memory cache for the test PC AT from 256K bytes to 640K bytes, and I enabled the 386 Turbo's ROM BIOS and DOS cache support.

As the test results show, both boards provided a dramatic improvement over the performance of the plain "vanilla" PC AT, although the 386 Turbo was faster than the Inboard 386: The Inboard 386 improved the performance of my 8-MHz PC AT by between 1.9 and 2.3 times, while the 386 Turbo's improvement was in the range of 2.2 to 2.8 times. I would guess that the 386 Turbo is faster because it uses all its memory as a cache from which you can run the ROM, BIOS, and so on, whereas the Inboard 386's ROM and BIOS are executed from the

continued

Inboard 386

Type
80386 accelerator board

Company
Intel Corp.
Personal Computer Enhancement Operation
5200 Northeast Elam Young Pkwy.
Mail Stop CO3-07
Hillsboro, OR 97124-6497
(503) 629-7369

Size
4½ by 13¼ inches

Features
Processor: 80386-16 running at up to 16 MHz with zero wait states; 80286 socket adapter/connector and cable; two chip pullers; replacement motherboard crystal oscillator to upgrade 6-MHz PC ATs to 8 MHz
Memory: 0K bytes, expandable to 1 megabyte (using 120-ns 256K- by 1-bit chips) on the board and up to 3 megabytes with an extra-memory piggyback board; supports EMS and 386 extended-memory specifications (16 megabytes directly addressable by the 80386)

Hardware Required
IBM PC AT (6 MHz or 8 MHz), Tandy 3000, or Compaq Deskpro 286 with at least 512K bytes of RAM

Software
Utility programs to change operating speed, use expanded memory, handle software errors consistently, and verify that the 80287-10 math coprocessor has been correctly installed

Options
80287-10 math coprocessor: $495
1-megabyte piggyback memory board: $645
2-megabyte piggyback memory board: $1145

Documentation
100-page installation manual;
25-page coprocessor manual

Price
$1795; $2295 with 1 megabyte of on-board memory
Installation kit (required): $200

386 Turbo

Type
80386 accelerator board

Company
American Computer and Peripheral Inc.
2720 Croddy Way
Santa Ana, CA 92704
(714) 545-2004

Size
3¾ by 13¼ inches

Features
Processor: 80386-16 running with one wait state at up to 12 MHz on a 6-MHz PC AT and up to 16 MHz on an 8-MHz PC AT compatible; 80286 socket adapter/connector and cable
Memory: 1 megabyte of memory (120-ns 256K- by 1-bit chips), not expandable; 100 percent hit rate claimed; 16 megabyte-per-second bandwidth on an 8-MHz PC AT;
Phoenix Technologies 80386 ROM BIOS chips included in case of BIOS conflict with the board

Hardware Required
American 286-A, IBM PC AT (6 MHz or 8 MHz), or other PC AT compatible (not specified); no minimum memory requirement

Software
Utility programs to control the default clock speed, control the high-speed cache memory, enable ROM BIOS execution from cache memory, and allow work with non-IBM EGA boards

Documentation
43-page installation manual

Price
$1695

motherboard. Subjectively, the discernible difference between the two boards was negligible. Both were quick, and they substantially improved the command-completion waiting time of processor-intensive applications, like AutoCAD. The boards also ran nearly as fast as—and, in some cases, faster than—the Compaq Deskpro 386.

I did not use the Inboard 386's optional 80287-10 math coprocessor during the benchmark tests. However, the coprocessor provided a dramatic speed improvement when I worked with applications that made heavy use of floating-point numbers; I was able to recalculate large spreadsheets 3 to 4 times faster with the 80287-10 installed than I could when it wasn't in place.

I also performed a standard floating-point benchmark (written in Lattice C) for calculating Whetstones per second (wps), and I obtained the following results: The plain 8-MHz PC AT produced 158,000 wps without a coprocessor and 211,000 wps with an 80287 coprocessor installed, the 16-MHz Inboard 386 produced 249,000 wps without a coprocessor and 341,000 wps with the 80287-10 installed, and the 386 Turbo produced 257,000 wps without a coprocessor and 281,000 wps working with the PC AT's existing 80287.

But Do You Need One?

Overall, both the Inboard 386 and the 386 Turbo turned an 8-MHz PC AT into a computer that rivals the speed of the new 80386 machines. However, a new 80386 machine or a new 80386 motherboard both have advantages over an accelerator card that can't be measured by processing speed, such as the availability of 32-bit 80386 slots. These 32-bit slots will, in the future, hold faster RAM and other accessory cards that you'll miss if you opt for an accelerator card in your PC AT. A new machine or motherboard may also offer a better overall system design and board layout, which is especially true if you have a marginal PC AT clone.

At $1695 for the 386 Turbo and $2495 for a similarly equipped Inboard 386, both of these cards are probably too expensive for a user to consider buying them along with an inexpensive PC AT clone; the cards may not work in such a clone, and the combined cost comes pretty close to that of a new 80386 machine. For these reasons, neither card is a particularly good value if you are just getting into the PC AT market.

If you own a relatively old PC AT or one that will require new conventional memory chips, a bigger power supply, or a new disk drive to take advantage of the power supplied by an 80386 accelerator, you're probably better off buying a new 80386 machine.

If, however, you are among the large group of users of existing fully equipped PC ATs, the Inboard 386 and the 386 Turbo may offer just the performance boost that you need for a lot less money than a new 80386 machine or 80386 motherboard.

Which board should you buy? If you are trying to squeeze out the last bit of performance from a DOS program and don't care about providing EMS or extended memory as part of your purchase, consider the less-expensive 386 Turbo and then camp out on American's technical-support phone lines and demand a step-by-step installation guide to replace the current poor installation manual.

If you want to add additional EMS and extended memory at some point without buying another memory card to take up a precious PC AT slot, I'd suggest the Intel Inboard 386. While it is not as fast as the American 386 Turbo, it is, nonetheless, *fast*. It also has a superior installation manual and comes with Intel's better technical support. ■

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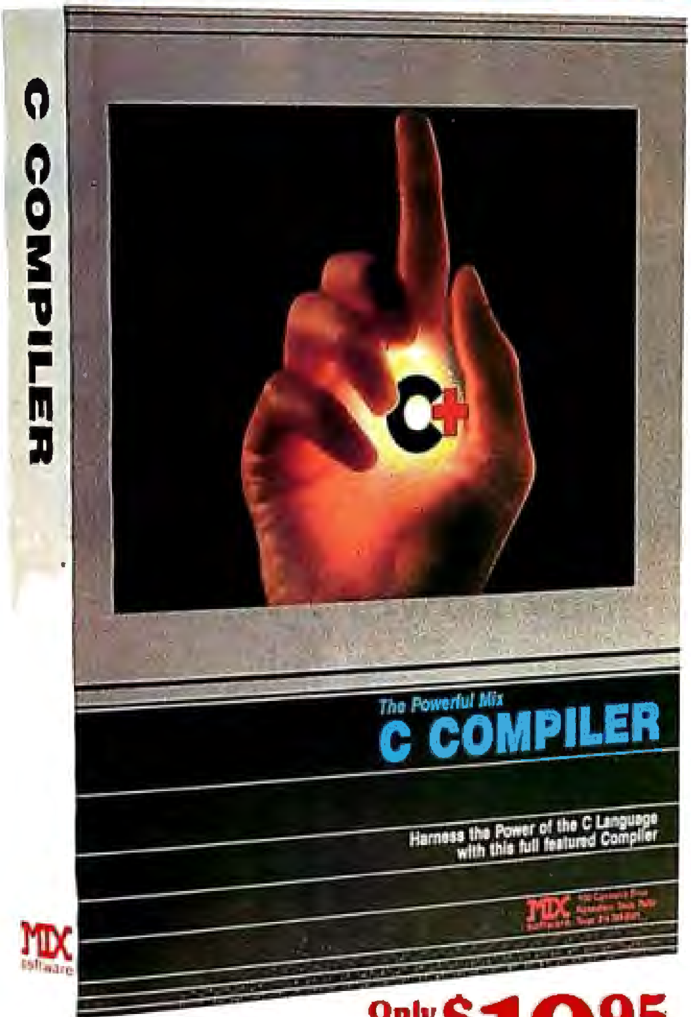

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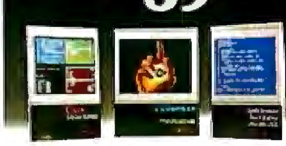

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Macintosh C Compilers Revisited

Joel West

Some of these packages provide fast development cycles and compact code

The Macintosh world has changed considerably since the last BYTE reviews of Macintosh C compilers [Editor's note: *See "DeSmet C Development Package for the Macintosh" by Jonathan Robie in the August 1986 BYTE and "Five C Compilers for the Macintosh" by Tim Field in the November 1985 BYTE*]. The Macintosh product line now has four different Toolbox configurations: 64K-byte ROMs, 128K-byte ROMs, the Mac SE's 256K-byte ROM, and the Mac II's 256K-byte ROM. The Macintosh line also uses two microprocessors (the 68000 and the 68020), two optional coprocessors (68881 FPU and 68851 PMMU), and a wide variety of memory and disk options. This complexity of the product line emphasizes the need for an up-to-date compiler. Four of the latest C compilers for the Macintosh are Manx Software Systems' Aztec C68K-c version 1.06I ($499), Spectra Micro Development's Hyper-C version 4.0 ($100), Think Technologies' Lightspeed C version 2.01 ($175), and Consulair's MACC/MACC Toolkit version 5.05 ($425).

The November 1985 review of Macintosh C compilers examined earlier versions of MACC/MACC Toolkit and Aztec C. Lightspeed C and Hyper-C are two newcomers to the market. All the versions that I reviewed are targeted toward developing code for the Macintosh Plus using the Hierarchical File System (HFS) and 128K-byte ROM features. Consulair and Spectra Micro Development offer separate compilers, which I did not test, for 68020/68881-based systems using the 128K-byte ROM.

If benchmarks are important to you, skip ahead to table 3, where you'll find all the numbers. However, I must stress that I think benchmark results are overemphasized and are not as important as the compiler's other aspects. To me, the most important factor is how quickly you can get the job done right, which means that the compiler must be both reliable and productive. With that said, let's take a look at the four compilers. Table 1 shows a summary of compiler features.

The Compilers

Mac C, the first Macintosh-based C compiler, is now in release 5.05. The development system comes on four 400K-byte disks and is composed of a compiler, editor, and linker with library and header (`#include`) files. The package is accompanied by a 163-page manual (without addenda) that documents the compiler and the library interfaces. Consulair used Mac C to write Apple's original Macintosh 68000 Development System (MDS). MACC/MACC Toolkit's editor, linker, and resource compiler are the same as those for MDS, and MACC/MACC Toolkit comes with a modified version of the MDS manual that documents these applications. A less expensive version of the compiler, Mac C Jr. ($79.95) is also available.

Aztec C68K-c 1.06I comes on four 400K-byte disks. The system comes with a "shell" program that emulates a Unix environment, a compiler (cc), an assembler (as), a linker (ln), editors (z and MDS Edit), and header and library files. These are formatted for MFS installation. You can't install the compiler right out of the package on an HFS hard disk by dragging the floppy disks to the hard disk desktop; you must copy the floppy disk by using the Aztec cp application or by converting the names from `<folder>/<filename>` to `<filename>` after dragging the files from `folder` to the root directory.

The Aztec C68K-c compiler comes with more than 500 pages of documentation in a 5½- by 8½-inch three-ring loose-leaf binder. I found the size and organization of this manual to be intimidating, mainly due to its large, independently numbered sections. Unless you can remember the order of the sections, the numbers don't help you find a specific piece of information.

Since the November 1985 review was written, Manx Software Systems has removed copy protection from Aztec C. An introductory version of the compiler, called C-Prime ($75), is also available. [Editor's note: *As this review went to press, Manx announced version 3.4 of its Aztec C68K-c compiler, which can generate 68020 code and support Mac SE and Mac II traps. It also has TMON debugger compatibility.*]

Lightspeed C 2.01 comes on three 400K-byte disks. The editor, compiler, and linker are merged into one large application program, and the compiler comes with the typical entourage of header and library files. The 400-page bound manual for version 1.0 is supplemented by a 64-page addendum for version 2.01.

Hyper-C 4.0 comes on a single 800K-byte disk. The development software consists of an editor, compiler, assembler, linker, librarian, and library and header files. The documentation is spread out among seven unbound photocopied handouts and is supplemented by a version 4.0 addendum. The documentation and header and library files cover a small fraction of the Mac's Toolbox and operating system.

Programming Environments

The four compilers take radically different approaches toward building Macin-

continued

Joel West (P.O. Box 2733, Vista, CA 92083) formerly developed and supported Simscript II.5 compilers for CACI Inc.-Federal. He now writes about Macintosh development and is the author of Programming with Macintosh Programmer's Workshop *(Bantam Books, 1987).*

Table 1: *Features of the four Macintosh C compilers.*

	MACC/MACC Toolkit	Aztec C68K-c	Lightspeed C	Hyper-C
Source code for standard library	Yes	Yes	Yes	Yes
Source code for interface library	Yes	No	No	Yes
Register variables	Yes	Yes	Yes	Yes
Floating-point math	Yes	Yes	Yes	Yes
User interface	Separate	Line-oriented	Integrated	Separate
MacsBug symbols	Yes	Yes	Yes	No
MDS .Rel	Yes	Converter	Converter	No
Intelligent linker	Yes	No	No	No
In-line assembler	Yes	No	Yes	Yes
Produce assembly output	Yes	Yes	No	Yes
Stand-alone assembler	Yes	Yes	No	Yes
Assembler equates	Yes	Yes	No	No
Multiple-file search	No	Yes	Yes	Yes
Interactive command interpreter	No	Yes	No	Yes
Batch command interpreter	Yes	Yes	No	No
Object librarian	Yes	Yes	Yes	Yes
RMaker	Yes	Yes	Yes	No
ResEdit	No	Yes	Yes	No
MacsBug	No	Yes	Yes	No
Example programs	13	10	5	10
68020/68881 support	Additional cost	No	No	Additional cost

tosh programs. MACC/MACC Toolkit and Hyper-C start with a single Macintosh application, the editor, and use a Transfer menu within the editor to launch the compiler and linker. The development cycle is helped somewhat in Mac C by menu items for `compile <filename>` and `link & go <filename>`.

Aztec C68K-c is based around a CLI-oriented shell that includes a wide range of built-in and auxiliary utilities. If you know the Unix shell, you already know how to use Aztec C; similarly, if you hate Unix, you'll hate the Aztec shell. There is no editor in the shell; instead, you go directly from the shell to Z (a character editor, like Unix's vi) or MDS's Edit.

Lightspeed C has a much more innovative approach. The compiler is an integrated windowing environment with windows for the editor and linker. Each program is a "project" that consists of source and library files. The `Run Menu` command automatically compiles and links only what's necessary and then runs the program. A separate command, `Build Application`, builds a double-clickable application that you can run from the Finder.

How are errors handled? The best method is MACC/MACC Toolkit's; it puts the error messages in a file. This file is automatically opened along with the offending source file. Lightspeed C puts up an alert at the first error, stops compilation, opens the editor window (if it is closed), and selects the objectionable line with the editor's insertion bar. Hyper-C takes a similar approach by transferring from the compiler back to the editor application and placing the editor's insertion bar at the questionable line in the source file. Aztec C68K-c clears the screen and displays the error messages, pausing after each five messages. Unfortunately, you lose these messages when you transfer to the editor to correct the problem.

Interfaces and Libraries

By far, the most important aspect of a development system is how it handles interfaces to the Macintosh software. These differences are summarized in table 2. All four systems allow you to declare your own Macintosh Toolbox traps; this is extremely helpful when you have a manual for a new ROM call but the compiler vendor has not yet updated the interface. Lightspeed C and Hyper-C enable you to directly declare low-memory globals, such as `MemTop` and `ApplZone`, although the other two compilers can use macros to provide this capability.

Aztec C68K-c and Hyper-C use declarations in the library header files to declare trap interfaces. To speed up compilation, both MACC/MACC Toolkit and Lightspeed C have built-in trap declarations and use the header files only for data structures and glue routines. None of the compilers validate the parameters to all Macintosh traps and glue routines, something that would save a tremendous amount of debugging for most Macintosh C programmers.

Of the four compilers, Lightspeed C has the most complete implementation of the standard C functions, with MACC/MACC Toolkit and Aztec C68K-c a close second and third, respectively. From looking at table 2, you'd probably conclude that Hyper-C should rate better than Aztec C68K-c, except that Hyper-C doesn't support the standard Unix I/O functions.

The Hyper-C documentation makes a point of not supporting standard Unix I/O functions and does not include `fprintf`, `scanf`, or, for that matter, a `stdio.h` file. To compile the benchmark programs, I made a dummy `stdio.h` file that simply included Hyper-C's `std.h` file.

Documentation and Support

Both Lightspeed C and Aztec C68K-c offer complete documentation for the standard C libraries, with one page per function (or group of macros) in the style of Unix manuals. The MACC/MACC Toolkit and Hyper-C manuals offer sketchy information in this area: Functions are grouped several to a page with a terse explanation of their purpose and the arguments that they accept.

All the compilers' documentation except Hyper-C's include a table of contents and an index. However, the organization of the Aztec C68K-c manual is nearly as confusing as the Hyper-C handouts. The layout of Lightspeed C's version 1.0 manual is great, but sifting for updated information through the stapled version 2.01 addendum makes things inconvenient. Consulair includes most of the necessary information for MACC/MACC Toolkit in a single spiral-bound manual that is slightly thicker than the Macintosh owner's manual and is supplemented by a utilities manual and a 68000 quick-reference booklet.

Both Manx Software Systems and Think Technologies maintain professional technical-support departments, which are staffed during east coast business hours. I experienced some problems reaching these support staffs, but both seemed knowledgeable and cooperative for the most commonly found problems. Manx Software Systems also offers a bulletin board and a BIX conference; the latter allows users to share experiences.

Consulair has a radically different approach. Only one hour of technical support is available each day (from 1 p.m. to 2 p.m. Pacific time), but the person answering the phone is Bill Duvall, the company's president and technical wizard. More advanced developers who need less technical support may prefer being able to deal directly with the expert.

The technical-support policy for Hyper-C is, at best, unknown and, at worst, nonexistent. On three consecutive weekdays, my calls to the company's only published phone number went unanswered either by a human or an answering machine. [Editor's note: *While this review was being written, Spectra Micro Development began marketing the Hyper-C compiler, which had been previously marketed by WSM Group. We were able to reach marketing and support for Hyper-C by calling Spectra's number at (602) 884-7402. However, until we discovered this fact, we were unable to contact anyone at WSM Group's number.*]

My int Is Faster than Yours

Each C implementation involves a decision on your part as to how to map the language-defined standard data types to the machine architecture. All four compilers represent byte, short, and long as signed 8-, 16-, and 32-bit quantities, respectively, and they support unsigned versions.

For the Macintosh/68000 architecture, a minimum of 24 bits is required for direct addressing, making 32 bits the only choice for pointers, such as char *string. Not surprisingly, the size and representation of pointers are the same for all the compilers. The only latitude in data types is in choosing the size of an int; the natural size can be a short or a long.

MACC/MACC Toolkit and Hyper-C have the long representation, which means that undeclared functions, as well as constants passed as parameters, default to 32 bits. The 32-bit int size is standard for all modern Unix C compilers and is appropriate for the Motorola 68020 architecture, which has become increasingly important for Macintosh programs.

Aztec C68K-c and Lightspeed C use 16-bit int values. This is the most efficient and natural size for the original Macintosh's 68000, since it does not include 32-bit multiply or divide instructions. The ROM interfaces, which were designed for Lisa Pascal, also make extensive use of the 16-bit Pascal INTEGER type. MACC/MACC Toolkit also has a 16-bit int compile option, giving it the best of both worlds, but you must be careful when using library interfaces that expect 32-bit values.

Table 2: *Macintosh interface support and C language implementation features of the four compilers.*

	MACC/MACC Toolkit	Aztec C68K-c	Lightspeed C	Hyper-C
User-definable traps	Yes	Yes	Yes	Yes
Direct low-memory globals	No	No	Yes	Yes
Trap declarations	Built-in	Headers	Built-in	Headers
Interface strings	Pascal	Pascal	Pascal	Pascal
Interface checking	Yes	No	Partial	Yes
Pascal string literals	Yes	Yes	Yes	Yes
Pascal functions	Yes	Yes	Yes	Yes
sizeof(char)	8	8	8	8
sizeof(short)	16	16	16	16
sizeof(int)	32 or 16	16	16	32
sizeof(long)	32	32	32	32
64-bit integer	Comp			Extended Int
sizeof(char *)	32	32	32	32
sizeof(float)	32	32	32	32
sizeof(short double)			64	
sizeof(double)	64	64	80	64
sizeof(extended)	80			80
Bit fields	Yes	No	Yes	Yes
Enumerated types	Yes	No	Yes	1
Stack-variable initialization	Yes	Yes	Yes	Yes
Structure assignment	Yes	Yes	Yes	Yes
Structure-passing	Yes	No	Yes	Yes
void	Yes	Yes	Yes	Yes
void *	No	Yes	Yes	Yes
ANSI function prototypes	No	No	Yes	No
Standard Unix I/O functions	Yes	Yes	Yes	No

1 Nonstandard syntax used.

The same situation occurs with floating-point data. The Standard Apple Numeric Environment (SANE) defines three floating-point data types: 32-bit real, 64-bit double, and 80-bit extended. All calculations are done in extended format, but operands can be converted to and from the shorter formats. Any Macintosh program should do all floating-point calculations in extended format unless memory space is a problem.

All four compilers define float as the 32-bit data type, and all but Lightspeed C define double as the 64-bit type. MACC/MACC Toolkit and Hyper-C support extended as the 80-bit type, while Lightspeed C uses double for 80 bits and short double for 64 bits.

Comparing Apples to Apples

I ran a set of seven benchmarks for each compiler: Sieve, Sort, Fib, Interface, Float, Savage, and Fileio. Several of these benchmarks were also used in the earlier BYTE reviews of Macintosh C compilers, but the results may not be directly comparable due to the changes in the Mac's operating system. I ran the three integer-intensive benchmarks (Sieve, Sort, and Fib) both with and without register variables. I used a Macintosh Plus equipped with a Peak Systems' Plus-30 SCSI drive for the benchmark tests, using System version 3.3 and Finder version 5.4.

I performed the benchmarks in such a way as to make them both accurate and fair. I included two files, startup.c and done.c, in the benchmark source code. [Editor's note: *The source code for the benchmarks and the* startup.c *and* done.c *files are available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4.*]

continued

	MACC/MACC Toolkit version 5.05	Aztec C68K-c version 1.06I	Lightspeed C version 2.01	Hyper-C version 4.0
Type	Macintosh C compiler	Macintosh C compiler	Macintosh C compiler	Macintosh C compiler
Company	Consulair Corp. 140 Campo Dr. Portola Valley, CA 94025 (415) 851-3272	Manx Software Systems Inc. P.O. Box 55 Shrewsbury, NJ 07701 (201) 542-2121	Think Technologies Inc. 135 South Rd. Bedford, MA 01730 (617) 275-4800	Spectra Micro Development P.O. Box 41795 Tucson, AZ 85717 (602) 884-7402
Computer	512K or 512Ke Mac; Mac Plus	128K, 512K, or 512Ke Mac; Mac Plus	512K or 512Ke Mac; Mac Plus	512Ke Mac; Mac Plus
Format	Four 400K-byte 3½-inch floppy disks	Four 400K-byte 3½-inch floppy disks	Three 400K-byte 3½-inch floppy disks	One 800K-byte 3½-inch floppy disk
Documentation	163-page user's manual; 148-page utilities manual; 68000 quick-reference booklet	514-page loose-leaf binder	400-page user's manual; 64-page stapled addendum	Stapled handouts
Price	$425	$499	$175	$100
Other versions	Mac C Jr.: $79.95 68020/68881 version: $600; $200 as an upgrade	Developer System: $299 Professional System: $199 C-Prime System: $75	None	68020 version: $195

The `startup.c` file obtains the system clock time before the benchmark program runs, and `done.c` obtains the system clock time after the program runs and then subtracts the two times, yielding the elapsed time. I employed neither a RAM disk nor a cache for any run-time test, and I built all test programs into Macintosh stand-alone applications.

I chose identical-size data types for those benchmark programs where it mattered. I modified the test programs that are limited by integer-compute speed (Sieve, Sort, and Fib) to use 16-bit short integers, and I used the extended 80-bit floating-point type for the three compilers that support it.

The Fileio benchmark performs sequential and random file accesses on a 65,000-byte file. To improve repeatability of the results, I first packed the hard disk using Peak Systems' version of DiskExpress. Even so, the margin of error is much greater than it is for the other benchmarks.

Benchmark Results

The complete benchmark results appear in table 3. The file sizes shown are the sizes of the resulting Macintosh application using the standard supplied libraries and default linker options.

Both Aztec C68K-c and Lightspeed C turned in essentially identical results for the Sieve test. The MACC/MACC Toolkit compiler's time was slightly worse, and Hyper-C placed last. Why? I looked at the machine code generated for the Sieve test when compiled with register variables, which I took from the assembly code output of the Aztec C68K-c and MACC/MACC Toolkit compilers. The major difference in instructions and speed comes from the compilers' different approaches to looping. MACC/MACC Toolkit uses the straightforward approach to handling C for loops: conditionally testing the termination condition at the beginning of the loop, and then unconditionally jumping back to the test at the end of the loop.

Aztec C68K-c uses the standard trick for unrolling a loop by conditionally looping once at the end, thus replacing two jump instructions with one. An additional check is needed the first time, unless the starting and ending values are constants, as is the case for one of the loops. Such optimizations make the reasonable assumption that any additional setup overhead is worth reducing instructions in the repeated part of the loop.

For the Fib benchmark, the results for Aztec C68K-c, Lightspeed C, and Hyper-C *worsened* when register variables were used. The culprit is a four-line recursive function where the overhead of loading and saving a value in a register outweighs the savings for just a few references to the variable's value. This shows that using register variables is not always a panacea.

Results for the two floating-point benchmarks exclude one important piece of data. Aztec C68K-c is limited to the 64-bit `double`, so both benchmarks were slowed nearly twofold by the conversion of results to and from the extended type. Also, the result of the Savage computation was 2499.99999968363, which reflects an error in the eleventh digit. This shows the cumulative effect of errors, since the 52-bit mantissa is accurate to 15 decimal digits. By comparison, all 15 digits of the compilers using the extended format were correct.

The Fileio benchmark required some

modifications to run on the MACC/MACC Toolkit compiler, which does not recognize the standard access-mode parameter for the `creat()` call. Lightspeed C required a redefining of its `abort()` function so that the benchmark's `abort()` could be used. I didn't run the Fileio test at all for Hyper-C, which lacks `creat()`, `open()`, and `lseek()`.

Table 3: *Benchmark timings and file sizes. The Sieve test measures how long it takes to run 10 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 a compiler's recursion while computing a Fibonacci series. Interface tests the efficiency of the function calls to the Toolbox ROM. Float measures the time it takes to do 140,000 floating-point multiplication and division operations. The Savage benchmark is from* Dr. Dobb's Journal, *September 1983, page 120, and it tests the speed and accuracy of transcendental floating-point functions. The Fileio benchmark exercises the I/O functions of the compiler by reading and writing to a 65,000-byte disk file. The Sieve, Sort, and Fib benchmarks were modified to use 16-bit integers, and the Float and Savage benchmarks were modified to support 80-bit extended data. Hyper-C has no Unix-style file I/O functions and could not be tested for the Fileio benchmark. A Mac Plus using System 3.3 and Finder 5.4 was used. All execution times are in seconds; file sizes are in bytes.*

Execution Times

	MACC/MACC Toolkit	Aztec C68K-c	Lightspeed C	Hyper-C
Sieve	6.22	5.86	5.62	6.42
register	3.92	3.23	3.25	4.36
Sort	12.15	11.64	10.14	12.06
register	10.32	9.83	8.27	10.33
Fib	30.69	24.73	24.72	27.46
register	30.63	28.42	28.41	35.98
Interface	63.49	50.83	57.22	57.30
Float	125.97	226.95	125.64	125.56
Savage	186.61	314.83	188.99	185.96
Fileio	54.72	147.23	104.35	N/A

File sizes
(Default options, without register)

	MACC/MACC Toolkit	Aztec C68K-c	Lightspeed C	Hyper-C
Sieve	13,056	9694	17,382	7822
Sort	13,568	14,146	17,832	12,199
Fib	13,056	9642	17,382	7754
Interface	17,426	9740	17,426	7862
Float	13,824	10,232	17,928	8322
Savage	14,080	17,586	21,564	7844
Fileio	15,872	10,616	20,984	N/A

Savage test

MACC/MACC Toolkit	Aztec C68K-c	Lightspeed C	Hyper-C
2500.00000000000	2499.99999968363	2500.00000000000	2500.00000000000

Compile-Time Performance

To prepare a compile-and-link test, I duplicated the logic from the Sieve and Savage programs 10 times each and included `startup.c` and `done.c` only once. The source file was 383 lines long, but Lightspeed C reported that the source file with headers totaled 591 lines.

Table 4 shows the total times required for the compilers to build an application, both with and without a RAM cache. The Aztec C68K-c test was done using a batch-style command file, while both the MACC/MACC Toolkit and Hyper-C tests began in the editor and used the Transfer menu to perform the compile and link.

Not surprisingly, the results directly correlate to the programming environment used. The integrated programming environment of Lightspeed C was somewhat quicker than the shell-driven Aztec C68K-c, but both handily trounced the two application-based systems (MACC/MACC Toolkit and Hyper-C).

Although the Lightspeed C values represent the complete time from first compilation to completion, the times in actual use would normally be even quicker. First, building an application and then running it is 50 percent slower than running the program directly from within Lightspeed C. You build the application only at the end of a session.

Both MACC/MACC Toolkit and Hyper-C suffered terribly from loading the compiler and linker applications and, in the case of Hyper-C, the intermediate assembler. As the results suggest, both benefited from a RAM cache and, presumably, from placing the applications in a RAM disk. The MACC/MACC Toolkit linker was particularly slow.

Although Hyper-C included an automatic one-command menu item similar to MACC/MACC Toolkit's, I was never able to get it to work using the proper combination of environment variables for directories and applications. This meant that I had to manually select each step and respond to several dialog boxes. I would expect that the actual results would be comparable to MACC/MACC Toolkit's if they were run unattended. [Editor's note: *We were eventually able to get the environment variables to work by placing the file specifying this information in the System Folder. Activating the compiler from a menu in the editor produced the results described by the author. However, activating the compiler from the editor by using the Command-key equivalent triggered a smooth exit from the editor, compilation and assembly of the source file, and halting at the Linker.*]

Room for Improvement

Each of the four compilers has its weaknesses. For MACC/MACC Toolkit, my number one complaint is that the linker is

continued

Table 4: *Compile and link times for building an application. An asterisk indicates that manual intervention was required (i.e., menu selections had to be made). All times are in seconds.*

Compiler	Time	Time with 128K-byte cache
MACC/MACC Toolkit	95	67
Aztec C68K-c	68	47
Lightspeed C	53*	43*
Hyper-C	110*	78*

painfully slow. The price is also steep, especially for the 68020/68881 version ($600).

Although its design is inherently un-Maclike, the Aztec C68K-c user interface could still be made better. It doesn't refresh the shell display after using a desk accessory. The shell and its document lack the proper 'BNDL' to give icons and double-clicking. Also, I found the lack of an editor in the shell inconvenient, as I had to bounce back and forth between the shell and the editor just to make a tiny change before recompiling. Overall, Aztec C68K-c gives the impression of being a quality compiler that just happens to be running on the Macintosh, rather than a quality Macintosh compiler.

Lightspeed C's standard search path is inconvenient if you plan to keep your source directories separate from the Think Technologies-supplied library directories. Worse, the compiler does not have an option for generating assembly code output, nor does Think Technologies supply a disassembler with the compiler. Lacking this type of output seriously hinders development work on large projects.

The most objectionable aspect of Lightspeed C isn't with the product, but with Think Technologies' lawyers. The shrink-wrap license requires all developers to include a Think Technologies copyright notice in a program dialog box, the documentation, the disk label, and "no less prominently than your own copyright notice."

Overall Recommendations

Lightspeed C and Aztec C68K-c are neck and neck in overall run-time performance, with MACC/MACC Toolkit about 10 percent behind. When it comes to floating-point performance, Lightspeed C, Hyper-C, and MACC/MACC Toolkit are the winners, with Aztec C68K-c severely crippled by a lack of support for extended floating-point performance.

For compile-time performance, Lightspeed C's integrated memory-resident compiler offers a tremendous boost in productivity. This makes it ideal for prototyping modules, but licensing complications with the copyright notice make it less desirable for commercial products.

MACC/MACC Toolkit is a complete product with solid documentation, an easy-to-use Macintosh interface, and a complete assembly package. It would be my clear personal choice from among these contenders if Lightspeed C didn't have such a preemptive advantage in development turnaround.

Aztec C68K-c is clearly suited for those who must move back and forth between different computers. The compiled output is first-rate, and, if you're trying to use different machines, its consistent, non-Macintosh interface would probably be an advantage.

Both MACC/MACC Toolkit and Aztec C68K-c are expensive, particularly given that Lightspeed C is of comparable quality at about half the price. All three are available at more reasonable prices from discount dealers, and both Consulair and Manx Software Systems offer more restricted systems at lower prices.

For those without much money, Hyper-C might seem to be a reasonable choice, as the compiler certainly produces reasonable code. However, the libraries and documentation are only partially complete. ■

386|ASM/LINK 1.1e

Matt Trask

The 386|ASM/LINK assembler package for the 80386 from Phar Lap Software ($495) is the first widely available set of development tools for the Intel 80386 microprocessor. The package includes a MASM-compatible assembler, a linker that is extended to support 32-bit records, a protected-mode debugger, and a protected-mode run-time program. This package should interest software developers planning to create system software or applications that use the 80386 protected mode or any of the new 32-bit instructions available in real mode.

The software comes on two floppy disks, which are not copy-protected, that include numerous examples, and the documentation consists of a 406-page user's manual in a three-ring binder. The package is available in versions for the IBM PC family, VAX/VMS, VAX/Ultrix, and Apollo and Sun workstations. The version that I reviewed was release 1.1e for the IBM PC, which runs on any 8086-family computer. It does not require an 80386 for development—only for testing and executing programs that use the new 80386 features. I used three different systems to test the software: a 9-MHz IBM PC AT with an American Computer and Peripheral 386 Translator plugged into the microprocessor socket and 2.5 megabytes of memory, an 8-MHz Kaypro 286i with 2 megabytes of memory, and a 16-MHz Intel iSBC 386/AT with 640K bytes of memory. All three systems had 30-megabyte hard disks with comparable speeds.

Overview

All assemblers are essentially the same. After all, what do they do other than translate op-code mnemonics into machine language? Perhaps the designers add a few features, such as macros, to make the user's life a little easier. Because the 386|ASM assembler was designed to be MASM-compatible and because compatibility and standards are important issues in programmer productivity, I will be paying particular attention to the degree of 386|ASM's compatibility with MASM in this review.

One notable departure from MASM is 386|ASM/LINK's command-line syntax that you use to execute the assembler, linker, and debugger. They all take their arguments from the command line, and you use Unix-style switches (i.e., a minus sign preceding the switch name on the command line) to control the available options. In addition, if you execute 386|ASM, 386|LINK, or the MINIBUG utility with no options specified, a help screen that describes all the options is displayed.

By default, the assembler and linker generate and link 32-bit code targeted for the 80386, but you can use command-line options to generate 8086 and 80286 code.

386|ASM

The 386|ASM assembler has all the usual things that you'd expect from an IBM PC-family assembler: generation of object and listing files, a full macro facility, and selection of the target microprocessor instruction set, to name a few.

The assembler enables you to control the creation of an error listing, define a search path for include files, specify the target microprocessor, and select case-sensitivity of symbols, all from the command line. Using the `-DEFINE <symbol>` switch, you can define a symbol at assembly time and thereby control conditional assembly without having to modify the source file. The -FULLWARN switch tells the assembler to do extra checking for the implied use of a segment register (i.e., you have not explicitly set segment registers with an ASSUME statement) and to flag forward references to short labels that would cause the assembler to generate NOP instructions on its second pass.

The 386|ASM assembler supports two new segment-type attributes, USE16 and USE32. These tell the assembler whether to generate address and data-size overrides when you use 80386-specific instructions. You can think of these directives as a way to control the D bit in protected-mode segment descriptors. The D bit is kept in a segment's descriptor-table entry; the 80386 uses the D bit to determine whether the default-operand and address-mode sizes are 16 or 32 bits.

This assembler provides two new segment-alignment types (used in the SEGMENT directive): DWORD increases the microprocessor's efficiency by preventing a 32-bit fetch on an 8- or 16-bit boundary, and PAGE4K forces code or data to fit within the pager's minimum 4K-byte granularity, reducing the number of page faults that the system must take in protected virtual mode. You control other segment-descriptor attributes on a per-segment basis by specifying the following access types: RO (read-only data), EO (execute-only code), ER (readable code), and RW (writable data).

DP is a new data directive similar to DD and DW that allocates storage for a 48-bit PWORD (pointer word). A PWORD is a 16-bit selector with a 32-bit offset that can address anywhere in the 80386's 64-terabyte address space.

The 386|ASM assembler's instruction-set directives—.386, .386C, and .386P—enable specific subsets of the 80386 instruction set that are appropriate for different types of programming, such as operating systems or applications. The .386 and .386C directives are synonymous; they cause the compiler to produce 80386 code but do not enable protected-mode instructions. The .386P directive enables protected-mode instructions, and the assembler generates code that accesses all the hardware features, including the debug, control, and test registers. When assembling for protected mode, the assembler considers segments and groups to be indexes into descriptor tables, not paragraph values for segment registers. These directives also enable the SIB (scale+index+base) addressing mode, available only on the 80386.

Two new features provided by 386|ASM, local symbols and redeclaration, are extremely valuable when managing large projects that have a great number of modules and public symbols. You can give local scope to any symbol within a procedure block by prefixing it with a pound sign (#). This is useful for targets of short jumps and for temporary variables.

If you declare a symbol as EXTRN (external), you can redeclare it as PUBLIC with the only restriction being that the symbol cannot be referenced between the line that declares it as external and the line that redeclares it as public. This feature simplifies the definition of module interfaces in large systems by enabling you to use one include file with all the symbols declared as EXTRN.

The object modules generated by 386|ASM conform to the Intel 8086 Object Module Format (OMF-86) with two simple extensions. Phar Lap Software has named this modified format Easy OMF-386. Phar Lap, in keeping with its philosophy of publishing all internal file formats, has included complete specifications of both extensions in the user's manual. The extensions are what the manual refers to as new "Loc" values for FIXUPP records and new SEGDEFs for DWORD and PAGE4K alignment types. Both new records are "hidden" within COMENT records that appear after the THEADR record and before all other object records. All other records are the same except that offset, displacement, and segment-length fields are 4 bytes long instead of 2 bytes.

386|LINK

The 386|LINK linker is quickly becoming a standard for 80386 development tools. At least two other commercially available products, MetaWare's 80386 High C and 80386 Professional Pascal compilers, generate code with the Easy OMF-386 extensions and use this linker. Other companies with language translators have announced their intentions of using this format.

You can control 386|LINK by command-line options or by use of a .LNK file containing linker instructions. Additional commands in the linker's command set are -HEX, -DUMP, -MINDATA, and -MAXDATA. The -HEX command causes the linker to output Intel Hex format files suitable for use with a ROM burner. -DUMP displays the contents of object modules in the .MAP file. -DUMP is intended for use as a customer support/debug tool, and, unfortunately, its output is in hexadecimal codes. It would be more useful if Phar Lap took the time to implement ASCII translations and object-record-type identification similar to the dump utility provided with Phoenix Computer Products' Plink86 linker.

-MINDATA and -MAXDATA initialize the memory-allocation fields in the .EXE file header. By default, DOS attempts to allocate all available system memory to an application at start-up time. These commands enable you to allocate only as much memory as the program will need for dynamic allocation at run time.

386|ASM/LINK version 1.1e

Type
Macro assembler, linker, debugger, and run-time environment for the 80386 microprocessor, including protected virtual-address mode

Company.
Phar Lap Software Inc.
60 Aberdeen Ave.
Cambridge, MA 02138
(617) 661-1510

Format
Two double-sided, double-density 5¼-inch floppy disks; not copy-protected

Computer
Any 8086/88/286/386-family computer running MS-DOS or PC-DOS with at least 256K bytes of memory and two floppy disk drives; a hard disk drive and 640K bytes of memory are recommended. Additional versions are available for cross-development with VAX/VMS, VAX/Ultrix, and Sun and Apollo workstations.

Documentation
406-page user's manual in a three-ring binder

Price
For MS-DOS: $495
For VAX/VMS or VAX/Ultrix: $3000 to $7000, depending on system size
For Sun/Apollo workstations:
Single Node: $1500
Network: $2000, plus $350 per node
386|Dos-Extender with redistribution license: $995

MINIBUG

MINIBUG is a subset of the DOS DEBUG.COM program. You use MINIBUG to run and debug real- and protected-mode programs. MINIBUG is adequate for debugging simple programs, but it will never replace the windowed symbolic debuggers that are now becoming popular.

Unlike the assembler and linker, you cannot run MINIBUG on an 8088 or an 80286; it requires an 80386 for operation. Phar Lap has announced a full-fea

continued

Table 1: *Benchmark results for 386/ASM versus MASM. All timings were done on an Intel iSBC 386/AT running at 16 MHz. The first test involved assembling a 20K-byte source code file. The second test involved assembling a set of 26 library functions, each around 2K bytes long, using the DOS* FOR. . .DO *command. All times are in seconds.*

20K-byte device-driver start-up module

Command Line	Time
MASM DRVRHDR;	2.58
386/ASM -8086 -NOLIST DRVRHDR	9.33

26 library functions

Command Line	Time
FOR %D IN (*.ASM) DO MASM %D;	29
FOR %D IN (*.ASM) DO 386/ASM -8086 -NOLIST %D	70

tured symbolic debugger, called 386|DEBUG, that will use the 80386 breakpoint registers to provide data watchpoints. [Editor's note: *At the time of this writing, Phar Lap was anticipating a formal release date of July 10 for 386|DEBUG. The price will be $195.*] It is based on MINIBUG but includes the Assemble command, which is missing from MINIBUG. As its name implies, Assemble lets you enter assembly language mnemonics that are translated to machine code and loaded directly into memory.

Extensions from DEBUG.COM include byte, word, and double-word forms of the Dump and Enter commands. You can access registers in their 32-bit form by using the RX variant of the Register command. Typing a question mark at the command prompt provides a screen full of on-line help.

MINIBUG will trap divide-by-zero, overflow, illegal op-code, and segment-protection violations that occur during the debugging of a program. The user's manual states that the debugger cannot trap bound, double-fault, invalid TSS (task state segment), stack-fault, page-fault, or coprocessor errors "because of conflicts with BIOS ROM." Phar Lap told me that MINIBUG will now trap all these faults.

RUN386

RUN386 provides a protected-mode run-time environment in which you can execute protected-mode applications developed with 386|ASM and 386|LINK on any 80386-based DOS machine. It is not an operating system and does not pretend to be. This run-time monitor layers itself between your protected-mode application and DOS, allowing nearly full access to DOS services by switching the microprocessor back to real mode when your application makes DOS calls.

When you start RUN386, it initializes a Global Descriptor Table (GDT), a Local Descriptor Table (LDT), and an Interrupt Descriptor Table (IDT). Then it loads your application into memory and passes command-line arguments to it. Finally, it switches the microprocessor into protected mode and transfers control to your application. Interrupts generated by the program are fielded by RUN386 and handed off to the real-mode interrupt service routines (in DOS).

RUN386 ensures that the program's run-time environment contains descriptors in the LDT for access to all system memory under 1 megabyte, including the video region buffers. RUN386 sets the current privilege level (CPL) for your program to zero so you can access all features of the microprocessor, including privileged instructions and I/O devices. You should not attempt to access GDT segments, as these are used by RUN386 and MINIBUG.

In order for your program to use RUN-386, you must link it with the START-386.OBJ module provided by Phar Lap. You'll find the source code to this module and a few demonstration programs that show how to use it on the distribution disks. The start-up code first verifies that it is executing on an 80386 running in protected mode, and then it jumps to the _start_ symbol, which you must provide in your code.

RUN386 is currently limited to a 640K-byte maximum program size, but it allows you to access memory above 1 megabyte (although you can access this memory as data only). In addition, it does not respect VDISKs or EMM (expanded-memory-manager) emulators that use memory above 1 megabyte. RUN386 extends DOS calls from protected mode to use 32-bit offsets.

Phar Lap sells a product called 386|DOS-Extender ($995) that you install in an 80386 system to execute protected-mode applications as if they were real-mode applications. This is a separate product that includes redistribution rights, so you can package it with your new protected-mode programs. I was unable to test the product for this review.

Documentation and Support

The 386|ASM/LINK documentation is not a tutorial on assembly language programming—it assumes you have a knowledge of assembly language programming and 80386 architecture. However, as assembler manuals go, this one is quite complete, with much tutorial material. If you've had exposure to any other assembler, you should have no trouble getting up to speed with this product.

Chapter 11 of the 386|ASM section of the user's manual is a thorough discussion of programming the 80386. It includes real-mode concepts, such as segments, dedicated-purpose registers, segment overrides, the use of the ASSUME directive, and register initialization by the MS-DOS loader. The chapter also covers protected-mode concepts, such as descriptor tables, paging, and the use of segment aliases to access code as data. One of the more difficult topics treated in the manual is the mixing of USE16 and USE32 segments within a program. The manual does a good job of explaining the act of mixing the two, but this is by no means a trivial topic. If you want to become familiar with USE16 and USE32, there's no substitute for coding your own programs and trying them out first hand.

In the discussion of real-mode programming, the manual says that there is "no way to get around the segment size limit of 64K bytes imposed in real mode." However, a recent discussion in the BIX os386 conference describes a technique of putting the 80386 into protected mode and loading the segment descriptors with limits greater than 64K bytes. Upon returning to real mode, you will find that these values are still in place, allowing the use of 32-bit overrides on op codes to address larger segments. One use of this technique could be to use the FS and GS registers to do block moves of data from above 1 megabyte rather than using the PC AT's INT 15H block-move function. One caveat, however: The Intel representative in the conference has posted a strongly worded message that advises against doing this if you desire future 80486 compatibility.

Phar Lap includes formats for .EXE and .HEX files in the linker section of the user's manual. The indexes for all sections are a treat by PC manual standards. My only complaint is with the minimal instruction-set reference, but even that's not too bad, since you shouldn't program the 80386 without Intel's *Programmer's Reference Manual* within reach.

Benchmarks

How do you meaningfully benchmark an assembler? A Sieve test may be adequate for comparing the quality of code generated by C compilers, but the code generated by a nonoptimizing assembler and its execution speed have no bearing on the assembler itself.

I think a more meaningful benchmark is an assessment of the program's MASM compatibility. In addition to this assessment, I compared assemble times for MASM and 386|ASM, including the time it takes to load the assembler from a hard disk. As table 1 shows, 386|ASM is about three times slower than MASM when assembling the same 20K-byte source file. This is partially due to the increased loading time for 386|ASM, which is about twice the size of MASM. The program's authors claim that most of this is caused by the error checking the assembler does. There is really no way to make a judgment on this performance disparity until a new version of MASM comes out with full 80386 functionality.

The problems I found with MASM compatibility usually occurred because Phar Lap followed the MASM documentation rather than the actual behavior of the MASM assembler when creating 386|ASM/LINK. When I assembled lines including `ESC EQU 1Bh` and `LOCK DW 0`, MASM did not complain, and the program worked as expected. The 386|ASM assembler complained of syntax errors because `ESC` and `LOCK` are reserved as mnemonics for op codes. The other difficulties I found generally had to do with a missing `WORD PTR` or `BYTE PTR` directive that MASM did not seem to care about.

The two main compatibility tests that I used were a 20K-byte source file that provided a C run-time interface. I use this file with Microsoft C to write loadable device drivers in C. It contains a good set of macros and a lot of `GROUP` and `SEGMENT` trickery that is necessary to satisfy the C compiler. The other test I used comprised 26 different library functions, each containing one C-style function of about 10 to 30 lines of assembly language source code (the total source code is around 60K bytes). The 20K-byte file had 11 errors of the type described above, and the library functions had no errors.

A Unique Product

The strongest feature of 386|ASM/LINK is its uniqueness; when no one else can do what you're doing, it really doesn't matter how fast you are. Comparing the speed differences between 386|ASM and MASM may not be entirely fair, since MASM cannot generate 80386 code. If you need to develop protected-mode code for the 80386, the 386|ASM assembler is one of the few options currently available. If you decide to purchase this product, you will be in good company; Phoenix Technologies and Softguard Systems are using 386|ASM as a development tool.

The only complaints that I have about the package are its speed, the limited object-module dump facility in the linker, and the lack of a complete instruction-set reference in the documentation. All in all, this product will be of value to any professional programmer or aspiring hobbyist looking to create a commercial product for the new 80386 market. ■

Matt Trask is a systems programmer at Stellar Computer Inc. (100 Wells Ave., Newton, MA 02159). He was one of the original programmers for Phoenix Technologies' V/pix and Control/386 products.

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SmartLink 2400B CCITT V.22bis/V.22, BELL 212A/103 Internal Card
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Configurable from COM1-COM4	YES	NO	YES	YES
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Speed Mismatch Message	YES	NO	NO	YES
Result Code Set	16	10	9	13
Dial Modifier W (Wait for Dial Tone 'PBX')	YES	YES	NO	YES
Dial Modifier @ (Wait for quiet answer 'DATA BASE')	YES	YES	NO	YES
Software Configuration Using Nonvolatile RAM	YES	YES	NO	NO
Leased Line Operations	YES	YES	NO	YES
One Phone Number Stored	YES	YES	NO	NO
2400 Baud Retrain Sequence	YES	YES	NO	NO
Long Space Disconnect	YES	YES	NO	YES

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Taipei International Electronics Show (October 6-12),
COMDEX/Fall '87 (November 2-6) booth No. H [illegible]

Inquiry 116

BackComm and SideTalk

Rob Fixmer

Two multitasking communications programs for IBM PC compatibles

Although different in their designs and user interfaces, LaSalle Micro's BackComm 1.3 ($149) and Lattice's SideTalk 1.00B ($119.95) are two background programs for the IBM PC and compatibles that do communications multitasking. As neither DOS nor the 8086 family of microprocessors support true multitasking, background communications software must try to divide the demands of two programs between the clock ticks of a single microprocessor.

This time-slicing challenge is magnified as the background-transmission data rate increases. The microprocessor sends only 300 bits per second to the serial port and out to the modem at 300 bps, leaving a lot of microprocessor time free for handling other tasks. However, at 9600 bps, a 4.77-MHz 8088 is virtually brought to its knees. Given these drawbacks, BackComm and SideTalk perform remarkably well.

For this review, I tested BackComm, which requires at least 192K bytes of memory, and SideTalk, which requires 128K bytes, on machines that use the four most common microprocessors in PC clones: a standard 4.77-MHz 8088 (in a Tandy 1200 HD), a switchable 4.77/8-MHz 80286 (in a PC's Limited PC AT clone), a nonswitchable 8-MHz 8086 (in an Amstrad PC1512), and a 4.77-MHz NEC V-20 (in a Zenith Z-150).

I chose this diverse group of microprocessors to determine what effect clock speed would have on the programs'. multitasking abilities. Although both programs run with MS-DOS 2.0 or higher and a wide variety of modems, I used a 300/2400-bps USRobotics Courier modem with a standard PC AT Hayes command set and MS-DOS 3.1 and 3.2. I conducted all 9600-bps tests with a null modem cable.

Comparing Features

Both programs use menu-driven interfaces that are coupled with script languages, which let sophisticated users write routines for automating communications tasks. SideTalk's 99-command BASIC-like script language, with its conditional statements, variables, and even a Debug utility, is substantially more powerful than BackComm's BackTalk script language, but a fundamental understanding of programming is necessary to use it effectively.

A major difference between the two programs is that BackComm locks you into its menu system, beginning with the Maintain menu of command sequences. SideTalk's menu is generated by its own script language, and, thus, you can customize it or reject it in favor of command-line operation. SideTalk also enables you to write windowed menus using its window-creation utility, which is called Popup. As many as three windows can be active at one time.

BackComm emulates Digital, TeleVideo, and Viewpoint terminals, a feature not offered by SideTalk. Both programs provide remote-access features, which enable you to go about your own work in the foreground while remote users log on and off of your computer and transfer files unattended in the background. BackComm's remote implementation is a full bulletin board system with electronic mail, nine security levels, and uploading/downloading features that use the Xmodem protocol.

SideTalk's remote operation is less sophisticated than BackComm's; it consists of a prewritten `CONFIG.SCL` file that defines only the function keys and establishes a single default pop-up window. Potentially, the program's remote operation is very powerful, since you can modify the program-like script language that runs it, called SCL (which stands for SideTalk control language), to create a full-featured BBS. SideTalk is also more accessible than BackComm; you can run it with or without password protection, and the remote users have access to virtually all SideTalk commands. BackComm confines the remote users to the parameters defined by its electronic mail system. Neither program allows remote users full access to the DOS level; a remote user can send and receive files but cannot run a program on your computer.

Sophisticated users may find BackComm's rigid menu system confining, as the menu is divided into options that bring up subsequent menus containing other options in a tree structure. Typically, there are four to six items per menu. Neophytes, however, will find BackComm easier to use and, in some ways, more powerful than SideTalk. For example, BackComm provides a learn mode, which stores the log-on sequence of a phone directory entry and then repeats it each time that the number is called. To invoke the learn mode, you type Alt-L. You are then asked to assign a name to the calling sequence you are about to create. After assigning a name, you press the Enter key. If a calling sequence with that name already exists, you can overwrite it or press Esc and abort the learn mode. The learn mode generates simple command sequences, as it uses only the `WAIT`, `SEND`, `CAPTURE`, `BREAK`, and `CHAIN` commands.

BackComm's phone directory design, with its myriad options, takes some getting used to (four screens of data are required for each phone number), but it is extremely powerful. In addition to such

continued

Rob Fixmer (Dallas Times Herald, *1101 Pacific Ave., Dallas, TX 75202) is a business writer and database programmer for the* Dallas Times Herald *and author of the* MEX-PC User's Guide *(NightOwl Software, 1985, 1986).*

BackComm version 1.3

Type
Background communications program

Company
LaSalle Micro Inc.
1254 Devonshire Rd.
Buffalo Grove, IL 60089
(312) 634-2288

Format
One 5¼-inch floppy disk

Computer
IBM PC, XT, AT, or compatible with at least 192K bytes of memory (256K bytes recommended), a serial port, and a Hayes-compatible modem (you can customize the program for other modems using the BCHIDEF program included in the help files); supports speeds up to 19,200 bps

Software Required
PC-DOS or MS-DOS 2.0 or higher

Language
C

Documentation
425-page user's manual

Price
$149

SideTalk version 1.00B

Type
Background communications program

Company
Lattice Inc.
2500 South Highland Ave., Suite 300
Lombard, IL 60148
(312) 858-7950

Format
One 5¼-inch floppy disk

Computer
IBM PC, XT, AT, or compatible with at least 128K bytes of memory, a serial port, and a Hayes-compatible modem; supports speeds up to 2400 bps

Software Required
PC-DOS or MS-DOS 2.0 or higher

Language
C

Documentation
166-page user's manual

Price
$119.95

standard parameters as word length, data rate, parity, and number of stop bits, you can define such things as different secondary phone numbers, alternate long-distance services, dialing prefixes and suffixes, and carriage-return definitions for each entry. BackComm also calculates long-distance telephone charges for each call placed. Since the design of the phone directory allows you to choose a voice option, you can use the program as a sort of computerized Rolodex that performs automatic dialing and cost analysis of voice calls.

The phone directory design is based on a DOS-like tree structure of subdirectories that goes to a maximum of six levels. Although each directory and subdirectory is limited to 57 entries, a total of more than 34 million phone number entries is theoretically possible. Realistically, though, the storage requirements of the phone directories would limit a user to about 10,000 entries on a 10-megabyte hard disk.

All this power comes at a price: BackComm requires much more memory and disk storage than SideTalk. Although BackComm will run on a two-floppy system, you are limited to relatively small phone directories and must do a lot of disk swapping for uploading and downloading files.

In contrast, SideTalk runs well on a two-floppy system. Memory usage is critical with background communications software, because the more you use for communications, the less you have left for foreground applications. BackComm has a minimum memory requirement of 192K bytes, but with data buffers, phone directories, and script files loaded, you'll need a minimum of 200K bytes (plus another 40K bytes if you intend to use the X.PC protocol). On anything less than a 640K-byte PC, you may well find yourself with too little memory to run a large application in the foreground. BackComm can be unloaded from memory; SideTalk doesn't have this capability.

BackComm does not offer a batch protocol, such as Modem7 or Ymodem. This means that if you're sending multiple files to another computer, you must keep switching from your foreground task to the background each time you want to send another file. SideTalk implements the Ymodem batch-transfer protocol, which allows you to queue a large number of files for continuous unattended transfer.

On the other hand, BackComm offers the X.PC protocol, which considerably increases transmission efficiency over packet-switched networks. For instance, transmitting a file over the PCPursuit packet-switched network using SideTalk's implementation of Ymodem took 4 minutes and 10 seconds. Transmitting the same file using BackComm's X.PC protocol took only 3 minutes and 20 seconds. The only problem with X.PC is that relatively few host systems offer it. Both programs, however, offer the Xmodem protocol with checksum or CRC error correction.

Performance

Both programs proved to be remarkably stable on all four microprocessors and against a wide variety of foreground tasks. Programs such as WordStar 3.31, XyWrite 3.12, WordPerfect 4.2, dBASE III Plus 1.1, Lotus 1-2-3 1.2A, SuperCalc 3.1, and even memory-resident programs, such as SideKick 1.56A and Instant Recall 1.64R, ran almost flawlessly. Some cut-and-paste operations with SideKick failed if I loaded the program prior to loading SideTalk and BackComm. The SideTalk user's manual specifies that SideKick should be loaded prior to SideTalk. However, when I tried loading the programs in this sequence, I still had the problem. [Editor's note: *Lattice technical support tried loading and running these programs in both sequences for us. Each time they ran SideKick 1.11C, it caused SideTalk to crash.*]

As I expected, BackComm's and SideTalk's foreground computation slowed considerably during multitasking, since the process was given, at most, only half the microprocessor's attention. Likewise, both programs' background data transfers were slower during multitasking.

I ran all the foreground and background tests on a Zenith Z-150 and an 8-MHz Amstrad PC1512. I modified the CONFIG.SYS file to increase the number of buffers to 15 and the number of files to 20. Some of the tests I ran were intentional worst-case scenarios; for instance, I ran a compiled QuickBASIC Sieve of Eratosthenes test in the foreground while transferring binary data in the background. Other foreground applications that I used included a second communications program that was addressing a different COM port and a sort of 560 records with dBASE III Plus. In all cases, the background data transfer must be started before the foreground application, or the foreground program will suspend execution when data transfer starts.

Both programs crashed when I booted a second communications program in the foreground (for example, I tried this with MEX-PC and ProComm), even though they were assigned to different COM ports. [Editor's note: *According to LaSalle Micro, two communications programs will not work without some alteration because they share the assigned IBM PC communications interrupt vector. Running BackComm's BCDOSP1R.COM program reassigns an unused interrupt vector to BackComm and avoids the crash condition. This procedure could possibly be used to solve other conflicts caused by programs that share unassigned interrupt vectors.*] All other non-memory-resident foreground programs that I tested performed well with background data transfers. BackComm and SideTalk were slightly less stable with memory-resident programs. While either SideTalk or BackComm was transferring data in the background, an attempt to do a cut-and-paste operation from SideKick's notepad to a word processor text screen resulted in a system crash.

Lattice claims that SideTalk is compatible with SuperKey. However, I found that when switching to background communications, neither SideTalk nor BackComm operated properly with SuperKey. Since both make extensive use of Alt-key combinations, each was unusable when I redefined the Alt keys in the foreground using SuperKey. A memory-resident DOS shell program, 1 dir, did not work with either program, while Instant Recall, a memory-resident text database, worked with both.

SideTalk and BackComm performed equally well on all four microprocessors regardless of clock speed, although they ran faster on the 8086 and the 80286. The foreground operation of the Sieve test slowed down by 52 percent under BackComm and by 59 percent under SideTalk. Simultaneously, background communications slowed by 23 percent under BackComm and by 28 percent under SideTalk.

More significant differences emerged when I ran a compiled QuickBASIC version of the Sieve test in the foreground while BackComm and SideTalk were transferring the same 15K-byte file at 2400 bps using Xmodem with CRC error checking. As a stand-alone program, the Sieve ran in 27 seconds and slowed to 41 seconds during the file transfer with BackComm. It slowed to 43 seconds during the SideTalk file transfer. Running the Sieve in the foreground also slowed the background file transfers from 190 characters per second with no foreground activity to 147 cps under BackComm and 137 cps under SideTalk.

The SideTalk file transfer incurred 28 errors with the Sieve running in the foreground. Although no two errors were consecutive and thus never threatened to abort the download, the time it took to resend the bad blocks probably accounted for SideTalk's extra slowdown. The errors occurred consistently over three tests of the same file downloaded on a clean phone line while the Sieve was running in the foreground.

However, it is important to note that the integrity of the received file was not impaired and that errors did not occur when I ran any other foreground program with SideTalk. Also, no measurable speed differences between SideTalk and BackComm occurred when any other program was running in the foreground, which suggests that the problems with the Sieve were the result of an incompatibility between compiled QuickBASIC and SideTalk. [Editor's note: *Many versions of BASIC assign themselves both the COM port and the communications interrupt vector when they are loaded. If your version of BASIC has a switch to disable*

continued

the COM function, you could try using it when running compiled BASIC programs. Microsoft technical support does not recommend using QuickBASIC with any terminate-and-stay-resident program.]

A database sort with dBASE III in the foreground slowed by only 30 to 31 percent under either program, and a Lotus 1-2-3 computation slowed by about 57 percent. However, the background file transfer slowed down by less than 20 percent. My typing at about 60 words per minute in the foreground never slowed the file transfer under either program by more than 3 percent. These results suggest that some foreground activities, such as word processing and spreadsheets, may be more appropriate than others, such as compiled BASIC programs, for multitasked communications.

Documentation

Computer communications can be confusing for the novice, and both BackComm and SideTalk lack a fundamental introduction in their documentation, which would have helped greatly. Both manuals contain a number of vague references, such as the definition of SideTalk's SCL program structure (which could have been avoided), and neither manual explains the use of transfer protocols in any detail. For example, the BackComm user's manual says that the program has 10 buffers, of which numbers 2 through 8 "allow up to seven additional calls to occur using the X.PC protocol." However, the manual never explains how you can use this feature, what other functions the buffers serve, or even what a buffer is, for that matter.

Both manuals could use a simple, step-by-step example of an upload or download procedure to acquaint the user with the notion that you must enter commands to both the remote computer and the PC before you can send or receive files. Through three revisions of the SideTalk manual, Lattice has failed to change the description of its LOADST.BAT program (which doesn't display the queries that the manual says it does) or to correct a serious error in the description of the `SA` command used to send a file with the simple ASCII protocol.

In Retrospect

BackComm and SideTalk are stable background communications programs that enable you to run foreground applications while simultaneously transferring data. Both perform time-sliced multitasking well on the 8088, 80286, 8086, and V-20 microprocessors. With either program, however, you must exercise caution in using memory-resident applications, and you should not run compiled BASIC programs in the foreground while transferring files with SideTalk.

For the neophyte, BackComm has a slight edge in both simplicity of use and the power of its phone directory. Its other advantages are terminal emulation and its use of the X.PC protocol, if the majority of your communications are over packet-switched networks. On the other hand, its inclusion of the Ymodem batch protocol, its interactive command option, and its powerful script language render SideTalk a more versatile option for the sophisticated user, especially if efficient memory usage is a consideration. ■

A CAD for All Incomes

Phillip Robinson

The hearts and CPUs of many designers have been captured by six of today's most popular CAD programs for the IBM PC and compatibles: At the low end of the price range are FirstCADD 1.0 ($49.95) and Generic CADD 2.01 ($99.95) from Generic Software and AutoSketch 1.0 ($79.95) from Autodesk; at the high end are AutoCAD 2.6 ($2850) from Autodesk, VersaCAD Design 5.2 ($2995) from Versacad, and CADKEY 2.11 ($2695) from Micro Control Systems.

In the IBM PC arena, CAD packages are more easily divided along price lines than between the two-dimensional and three-dimensional capabilities of the Macintosh packages. [Editor's note: *For a look at Macintosh CAD packages, see "Drafting, Drawing, and Design" by Phillip Robinson in the July BYTE.*] While less money predictably buys you less power, the inexpensive PC CAD packages offer a surprising number of features for less than $100. The more expensive packages combine two-dimensional and three-dimensional drawing with dedicated databases and even programming languages for just under $3000.

I tested all six programs on a PC's Limited 286[12], an ITT XTRA PC AT-compatible system, and a Compaq Deskpro 386. Each had 640K bytes of RAM and a 40-megabyte hard disk, and I used a Logitech C7 mouse and tested the programs with and without an 80287 coprocessor on each system. However, even at 12 MHz, the PC AT clones seemed surprisingly slow next to the Deskpro 386.

FirstCADD 1.0

FirstCADD 1.0 from Generic Software is easy to use and works with either the keyboard's cursor-control arrows or with a digitizer, such as a mouse, for input. The main drawing area is accompanied by a menu column on the right side of the screen, a command and status line at the bottom, and a cursor-position counter at the top left, showing the x and y coordinates. To draw, you can either select a command from the menu with the cursor or type in the command and coordinates from the keyboard. Most typed commands have two-letter abbreviations, such as `sl` for `straight line`. Other basic objects include points, rectangles, polygons, three- and four-point arcs, ellipses, and complex curves (or splines).

Once you draw an object, you can break (i.e., insert a gap into), change, erase, move, or copy it and change its color or type. The `Erase Last Line` command lets you back up one line at a time, erasing your most recently drawn images. If you want to work with more than one object at once, you can draw a rectangle and select all objects within it. Other commands let you measure the distance (`Measure Distance`), the angle (`Measure Angle`), or the area between specified points (`Measure Area`), but they do not enter the measurements as dimensions on the drawing. You can also combine objects into "components" (compound objects that can be manipulated on their own and stored in libraries) that you can save and reuse later, store as a library, scale, rotate, place, or remove as you would a single object.

FirstCADD's text commands let you select the font (it comes with one), color, size, rotation, and placement of characters. You can easily create or modify characters and save them for your own use.

The `Zoom` commands let you change the view by zooming out to the limits of the drawing or by moving in and out while centered on a specified point or a

continued

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Lotus 1-2-3 (2.0) and Symphony use RamFont to nearly double data display from 2,000 to about 3,400 characters by expanding the spreadsheet from 80 columns by 25 rows, to 90 columns by 38 rows—with no loss in scrolling speed.

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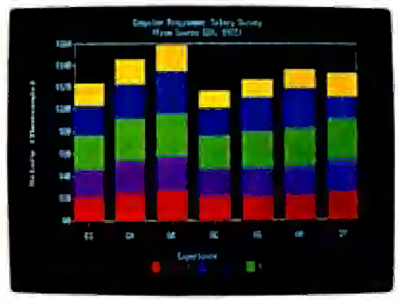

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Includes the three modes your software needs most:
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FirstCADD offers 10 drawing layers, two layer commands, and four utilities.

window, and you can revert to the previous viewpoint. You can specify the zoom value as a number (e.g., 0.5 to zoom in, 3.0 to zoom out). Pan lets you move within the two dimensions of the drawing. Redraw lets you clear up small mistakes that may creep into the visual display after a series of complex commands, such as the distortions that can occur when you edit intersecting objects.

FirstCADD offers 10 drawing layers and two layer commands, Set Current Layer for selecting the current layer (the one you're drawing on) and Display Layers for choosing the layers that you want displayed. The built-in utilities, Load Drawing, Save Drawing, Erase Drawing, and Plot Drawing, are self-explanatory. You can save in either Generic Software's or the ASCII file format.

Generic CADD 2.01

Generic Software's Generic CADD 2.01 shares FirstCADD's user interface, drawing objects, zoom commands, and object-edit commands, but it also has additional capabilities of its own. The Components menu adds Explode, Image, and List options. Explode breaks a component into its original parts, Image moves a component into a drawing as separate parts (like using Place and Explode simultaneously), and List shows you which components are available.

The Text menu lets you set the Aspect (i.e., the ratio of height to width) and Slant of the text, delete or replace text one character at a time, and choose from among its seven fonts. In addition to changing, erasing, moving, and copying the contents of a window, you can mirror, rotate, rescale, and save them and transform them into a text character.

Generic CADD also has a Layers menu; FirstCADD doesn't. Working with up to 256 layers, Generic CADD lets you select or display specific layers and erase, change, rotate, rescale, load, and save either specific layers or entire drawings. You can also Align a drawing to synchronize it to a digitizer.

Finally, the Utility menu contains access to advanced functions, including creating and loading Digitizer menus and employing batch files (i.e., ASCII files of Generic CADD commands and position specifications that you can call up at any time). You can save your present drawing as a batch file, or you can create a batch file using a text editor.

Generic Software offers some add-on programs for Generic CADD, such as AutoDimension, Drafting Enhancements-1 (which adds features such as extended snaps, trimes, and chamfers), Drafting Enhancements-2 (which adds solid fill and cross-hatching), Auto-Convert (for converting to DXF format, a special file format used by AutoCAD), Generic IGES (Initial Graphics Exchange Standard) for converting to IGES format, and Symbols Library (a library of predrawn parts). These programs fill Generic CADD out into a more complete CAD contender. However, while it makes an earnest run at high-end programs, such as AutoCAD and VersaCAD Design, it neither has, nor claims to have, their panoply of features or depth of control.

Features that are lacking from FirstCADD and Generic CADD include autodimensioning (I didn't test Generic CADD's AutoDimension add-on), a programming language other than the primitive batch-files feature (a standard feature on the high-end products), and an attached database for tasks such as materials billing (like VersaCAD Design has). They also have no built-in facility for transferring information back and forth to a mainframe or even a DXF or IGES translation facility to allow them to work with AutoCAD files. [Editor's note: *Generic Software has released Generic CADD 3.0 ($99.95) since this review was written. It includes DXF and IGES capabilities, named views, autodimensioning, solid fill, cross-hatching, and faster execution.*]

AutoSketch 1.0

AutoSketch 1.0, Autodesk's low-end CAD package, competes head-to-head with FirstCADD and Generic CADD. AutoSketch is compatible with AutoCAD, so you can move files back and forth between the two programs (you can save AutoSketch files in their own format or as DXF files), but their interfaces are completely different. In fact, the AutoCAD interface more closely resembles Generic Software's than it does AutoSketch's.

AutoSketch is easy to use—even easier than FirstCADD. Its configuration program is short and includes PostScript printers, and its short manual is lucid and aimed directly at novices. A quick-reference card shows and explains the options within the pull-down menus. The package even includes a dozen sample drawings on disk.

With its pull-down menus, AutoSketch works and feels like MacDraw rather than resembling the other products I reviewed. You can move the cursor with either the cursor-control arrows or a mouse, and the prompt line appears at the bottom of the screen. You can initiate some menu operations with key combinations for fast entry; for instance, you can begin to draw a circle by pressing Alt-F4.

The basic objects in AutoSketch are the arc, box, circle, curve (spline), line, point, and polygon. You can use "parts" (i.e., the components of FirstCADD and Generic CADD) as objects. You can enter text, though you may want to first set its height, baseline angle, obliquing angle, and width factor in the Settings menu. The Settings menu also lets you specify color (any of eight), Grid (spacing and on/off), Snap (spacing and on/off), Layer (any of 10), Attach (the same as tolerance in Generic CADD), Limits (drawing boundaries), and line type (any of 10, including dashes, dots, center, and so on).

Once objects are on the screen, you can select them with the cursor or by drawing a window around them. Then you can Erase, Group, Ungroup, Move, Copy, Stretch, Rotate, Scale, Mirror, or Break them. You can also change their properties, such as line type and color. The Undo and Redo commands let you rest easy about mistakes. Undo will back up through an entire series of operations, as far back as the beginning of your drawing session. Redo undoes an Undo; that is, you can select it several times in succession to step back through the most recent series of Undo requests.

The Zoom commands can show the full drawing, enlarge a specified area, Pan (i.e., shift the center of the drawing in two dimensions), zoom a numerically specified amount, and jump to the last view (the view previous to any zoom command). You can select the amount of zoom and clean up a drawing with an immediate Redraw. The Ortho command draws horizontal and vertical lines (Generic CADD has one also). The Measure menu contains options for measuring distance, angle, area, point position, and bearing and lets you list the properties of any object. AutoSketch has semiautomatic dimensioning: It can insert dimension lines that will automatically change if the drawing is later stretched.

AutoCAD 2.6

Version 2.6 of Autodesk's AutoCAD, the industry standard for PC CAD, is the first of the three high-end programs I reviewed. It is impossible to list all the options, features, subtleties, and variations of AutoCAD, VersaCAD Design, or CADKEY in a short review. Ranging

continued

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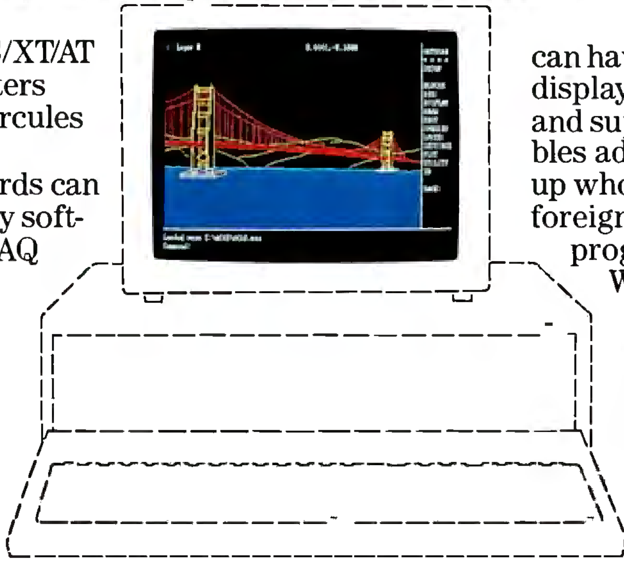

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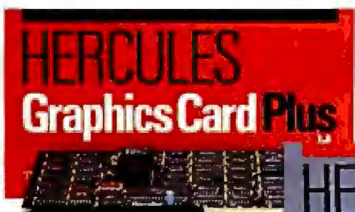

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VersaCAD Design has more three-dimensional modeling capabilities than any of the other packages.

from $2795 to $2995, they cost over 20 times more than their low-end cousins ($49.95 to $99.95). However, they offer advanced features, such as programming languages and integrated databases, on which I'll focus in this review.

AutoCAD 2.6 performs both two-dimensional and three-dimensional drafting. (Versions also exist for such powerful machines as the Sun workstations.) Since large drawings are paged to disk, you will want as much RAM as possible installed in your system. AutoCAD offers you the option of working in dual-screen mode (i.e., graphics on one display and text information, such as command prompts and menus, on the other).

AutoCAD's drawing interface resembles Generic CADD's, with a column menu on the right side of the screen, a drawing area in the center, and a command- and status-line region at the bottom. You can step through the layers of menus using the mouse or cursor-control arrows, or you can type in commands and specifications on the keyboard.

AutoLISP, an implementation of LISP, lets you customize AutoCAD, but you don't have to be a programmer to appreciate it. A number of companies are now producing AutoLISP programs and menus that you can use with AutoCAD just by installing AutoLISP on your system. If you are a programmer, you can add functions, filters, features, and application-specific templates to AutoCAD via AutoLISP. Autodesk calls this an "open-architecture" system that lets you build the CAD you need.

Nearly all of AutoCAD's object commands have more subtle possibilities than Generic CADD's. For example, you can inscribe or circumscribe polygons around a selected circle. Where Generic CADD has only lines, AutoCAD also has `Traces` (solid lines of a specified width) and `Polylines` (connected sequences of line and arc segments treated as a single entity). The program also enables you to draw filled solids, tori (doughnut shapes), and isometric circles.

You can use text in a variety of fonts, and you can stretch, compress, oblique, center, mirror, rotate, or justify text or draw it into a vertical column. Four fonts come with the program, but you can add more by creating your own.

The program enables you to erase and then retrieve objects with the `Oops` command. In addition, objects can be moved, copied, filleted (surfaces brought together in a concave junction), chamfered (grooved or beveled), rotated, scaled, trimmed and extended (to the dimensions of other objects), broken, or mirrored. You can change an object's properties, including line type, color, three-dimensional elevation, layer, and thickness, and you can divide an object into equal sections or explode it into component parts. An `Undo` command exceeds the capabilities of `Oops` and lets you step back by several operations.

AutoCAD's `zoom` and display-control commands resemble Generic CADD's. In addition, for three-dimensional drawing, AutoCAD lets you select your viewpoint in three dimensions so you can see drawn objects from any angle. AutoCAD does not yet have a full three-dimensional capability. It does, however, allow you to use z coordinate values to create lines and planes (displayed as wire frames, not filled areas) in three-dimensional space. When you register your version 2.6 of AutoCAD, you receive a bonus disk containing AutoLISP functions for drawing cones, domes, spheres, and other three-dimensional objects.

AutoCAD has special grids for isometric drawing and a whole series of object-snap modes for selecting the style of grid work, including `Nearest`, `Endpoint`, `Quadrant`, and `Tangent`. AutoCAD's "blocks" resemble Generic CADD's components and AutoSketch's parts; they are merely different terms for compound objects. AutoCAD offers a form of semiautomatic dimensioning for diameters, radii, lengths, centers, leaders, limits, and tolerances. It also has cross-hatching and pattern-filling.

The program incorporates a set of commands for calibrating a drawing tablet and a Sketch mode for freehand drawing. You can use command scripts, which are prewritten command sequences, to set up AutoCAD, and a pair of commands to grab and display `snapshots:` or `slides:` of the screen's contents. AutoCAD also has a timer to show you when a drawing was created and how much time you've spent editing it. You can save AutoCAD drawings as DXF files, DXB (binary drawing interchange) files, or IGES files.

VersaCAD Design 5.2

VersaCAD Design 5.2 from Versacad can perform both two-dimensional and three-dimensional drafting and requires nearly 6 megabytes of hard disk space. The two-dimensional module alone takes 2.5 megabytes, the three-dimensional module uses up another 1.5 megabytes, and the Bill of Materials database requires an additional half megabyte. Two unusual aspects of VersaCAD Design are its automatic Bill of Materials report generator and its built-in links to mainframe CAD systems.

The Bill of Materials generator provides sorted lists of parts, code numbers, descriptions, sizes, costs, labor units, and labor rates. You create the main tables of parts, and VersaCAD Design keeps track of them as the drawing changes, deriving calculated tables of costs, wage and labor usage, and so on. For interprogram communication, VersaCAD Design can translate between its own files and both IGES and DXF files. It can also work with text files.

VersaCAD Design resembles AutoCAD in many ways, including its user interface. VersaCAD Design has all the staples for two-dimensional drawing: menus, objects, layers, symbol libraries, windows, snapping, coordinate display, and so on. It can handle text, comes with six fonts (and you can create your own), and lets you `Move`, `Copy`, `Rotate`, `Scale`, `Delete`, `Undelete`, or `Explode` an object. You can also `Group` objects and perform most of the same operations on the group. VersaCAD Design has zooming and panning capabilities, as well as autodimensioning and cross-hatching. You can set object properties, including `linestyle`, `linedensity`, and `linewidth`, in more detail than in any of the other five packages, and you can specify units (metric or English, as well as the scale to be shown on the screen) and text formats. A series of commands on the Construct menu lets you draw new lines perpendicular to (`Normal`), parallel to (`Parallel`), or tangent to (`Tangent`) previous lines.

VersaCAD Design has more three-dimensional modeling capabilities than any of the other packages, with built-in drawing primitives, such as spheres, cylinders, polyhedrons, curves, and cones. You can manipulate objects in a variety of ways and see them in orthographic, wireframe, isometric, or perspective views with hidden lines removed. VersaCAD Design also lets you build your own three-dimensional objects by extrusion, sweeps, or by adding a z coordinate to two-dimensional objects. For realism, the color-shading feature lets you define a light source and the desired colors; VersaCAD Design then chooses a shading algorithm for the configured monitor. To output such drawings, VersaCAD Design supports film-recorder and laser-printer output using color shading or

continued

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Format	One 5¼-inch floppy disk; not copy-protected	Two 5¼-inch floppy disks; not copy-protected	Two 5¼-inch floppy disks; not copy-protected
Computer	IBM PC, XT, AT, or compatible with at least 256K bytes of RAM, MS-DOS 2.0 or higher, a graphics card, and either two floppy disk drives or one floppy disk drive and one hard disk drive; 8087 or 80287 math coprocessor recommended	IBM PC, XT, AT, or compatible with at least 384K bytes of RAM, MS-DOS 2.0 or higher, a graphics card, and either two floppy disk drives or one floppy disk drive and one hard disk drive; 8087 or 80287 math coprocessor recommended	IBM PC, XT, AT, or compatible with at least 512K bytes of RAM, MS-DOS 2.0 or higher, two floppy disk drives, and a graphics card (Hercules or IBM CGA- or EGA-compatible); hard disk drive recommended
Language	Pascal, C	Pascal	C
Documentation	121-page *Operator's Manual*	201-page *Operator's Manual*	56-page *User's Guide*; quick-reference card
Price	$49.95	$99.95	$79.95; a version that supports the 8087 and 80287 math coprocessors costs $99.95; an upgrade from standard AutoSketch costs $20.

black-and-white halftones.

A multitude of Versacad and third-party VersaCAD Design add-ons exist to interface with the fields of architecture, mechanical engineering, CAM, and others. [Editor's note: *Since this review was written, Versacad has released its add-on, VersaCAD/Mechanical ($495). It includes geometric tolerancing, enhanced dimensioning, and mechanical construction features.*] Some add-ons stem from CPL, Versacad's CAD programming language, which lets you perform two-dimensional, three-dimensional, and Bill of Materials operations. CPL is an interpreted language of statements, functions, and variables that you can use for calculations, writing programs, and customizing menus. It lets you add commands to the CAD package, customizing it to work with your application. You can reach it from any point within VersaCAD Design for immediate command or stored-macro execution. (You can create macros with a simple "record and play back" scheme.) CPL lets you access program variables, such as object properties, handle points, location, and message displays, as well as control the parallel and serial ports. You can write a CPL program using a text editor and then assign it to a single key for execution within VersaCAD Design.

CADKEY 2.11

CADKEY 2.11 by Micro Control Systems provides the same level of two- and three-dimensional power and features as AutoCAD and VersaCAD Design, but it is more directly tailored to mechanical drafting than the other two. It doesn't have VersaCAD Design's shading ability or AutoCAD's extensive programming language. [Editor's note: *CADKEY 3.0 ($3195) has been released since this review was written. It has a more comprehensive programming language than version 2.11 and adds shading as well. Other features include two-dimensional ordinate dimensioning, European and English drafting standards, fractional dimensioning, a unified database that allows transmission of interactively synthesized solid primitives to an engineering analysis and animation utility, and an on-line calculator supporting trigonometric and algebraic functions.*]

AutoCAD 2.6	VersaCAD Design 5.2	CADKEY 2.11
Autodesk Inc. 2320 Marinship Way Sausalito, CA 94965 (415) 332-2344	Versacad Corp. 7372 Prince Dr. Huntington Beach, CA 92647 (714) 847-9960	Micro Control Systems CADKEY Division 27 Hartford Turnpike Vernon, CT 06066 (203) 647-0220
Nine 5¼-inch floppy disks; U.S. version not copy-protected; international version has a hardware lock	Five 1.2-megabyte 5¼-inch floppy disks; not copy-protected	Seven 5¼-inch floppy disks; copy-protected (must be used with Software Interface Module, a special hardware plug for either a parallel port or an expansion slot)
IBM PC, XT, AT, or compatible with at least 640K bytes of RAM, one floppy disk drive and one hard disk drive, MS-DOS 2.0 or higher, a graphics card, and an 8087 or 80287 math coprocessor	IBM XT, AT compatible, or 80386 machine with 640K bytes of RAM, one high-density floppy disk drive and one hard disk drive (with at least 6 megabytes of free space), MS-DOS 2.1 or higher, a graphics card, and an 8087 or 80287 math coprocessor	IBM PC, XT, AT, or compatible with at least 512K bytes of RAM (640K bytes recommended), one floppy disk drive and one hard disk drive, MS-DOS 2.0 or higher, and supported graphics card; 8087 or 80287 math coprocessor recommended
C	C	C
426-page *Reference Manual;* 136-page *Installation and Performance* Guide; 10-page *Tutorial: How to Get Started in AutoCAD Without Reading the Manual;* 76-page *Programmer's Reference to AutoLISP; Introduction to AutoCAD* audio tape	653-page *User's Manual and Reference Guide; 292-page CAD Programming Language Reference Guide*; VersaCAD audio *tour tape*	417-page *User Reference Manual;* 40-page *Customization Guide*; 80-page *Hardware Setup Booklet*
$2850	$2995	$2695

CADKEY's user interface varies from AutoCAD's and VersaCAD Design's. The menu is still arranged as a column at the right side of the drawing area, but it has many more levels than the other packages. You can select menu items with the mouse or with the corresponding function key and return to the main menu at any time by pressing the Escape key; Backup lets you back up by one menu. At the top of the drawing area is a history line that lists all the selections you have made so far in any particular operation. You can perform many common operations with such Immediate Mode commands as Grid On/Off, Pan, Redraw, set the 2D/3D switch, change View/World coordinates, and others; you simply press Alt or Ctrl with the appropriate key. Six fonts are available for text.

The user interface is less intuitive than that of AutoCAD or VersaCAD Design, but, for some operations, CADKEY offers more options than they do, and its interface makes those options easy to identify. For instance, although CADKEY has basically the same set of primitive drawing entities as the other two (plus a few more, such as helices and three-dimensional spline curves), it offers some unique ways to manipulate them. You can select an object singly, in a group, or with a window (as in the other programs), but you can also select a Chain (i.e., a series of connected lines and arcs for which you need only select the start and end), and CADKEY will estimate all the

continued

links in between. Other options let you draw tangents, perpendiculars, or parallels to existing entities and trim, chamfer, and fillet entities. You can also save parts of a drawing on disk and pull them back into other drawings.

Zooming, dimensioning, notes, labels, title blocks, and cross-hatching are all included, as are drawing layers, scaling, grids, and snapping. CADKEY offers a wide variety of geometric calculations and analysis for determining the perimeter or the area of an entity. In line with its mechanical-engineering bent, CADKEY can also figure an entity's moment of inertia if you give it a reference axis.

The Status Window menu, which is directly beneath the main Selection menu's Position Menu, is always visible to let you control your drawing's view, level, color, line type, snap, and dimensions (two or three). You can also choose a view numerically. You can look at your drawing in many ways: Eight basic views (`Top`, `Front`, `Back`, `Bottom`, `Right`, `Left`, `Isometric`, and `Axonometric`) are predefined, and you can define your own views and add them to the menu. CADKEY can quickly switch between two-dimensional and three-dimensional views of the same drawing. The program can handle I/O with IGES (this requires an additional module) and DXF files.

CADKEY doesn't provide macros, but it has a built-in programming language, CADL (which stands for CADKEY advanced design language). CADL is useful for storing and retrieving entity data in ASCII files in the CADKEY database. It can also perform as a batch-command executor or as a rough macro facility, performing a series of CADKEY keystroke commands.

Money Is Power

While AutoCAD is the standard CAD program for the IBM PC and compatibles today with the largest installed base and a panoply of add-on software developers and books to support it, VersaCAD Design, CADKEY, and other available programs are successful direct competitors. Most CAD developers offer translations to and from AutoCAD's DXF file format, so compatibility is becoming less of a problem. However, the differences between interfaces and programming languages still exist among the programs in the $3000 price range.

At least half a dozen CAD programs for the IBM PC and compatibles are available for less than $100, including the impressive Generic CADD; I've discussed three of them here. AutoSketch is an inexpensive beginner's CAD program from Autodesk, the company that makes AutoCAD; it has much of the flavor of MacDraw.

Generic CADD is the star among the inexpensive packages and offers a surprising amount of power for a fraction of the price of AutoCAD or VersaCAD Design. FirstCADD is an even less expensive (and less powerful) CAD program from Generic Software, the makers of Generic CADD. If you're starting out on a budget, try one of these. If you then find you need more power, you should be able to take your files and much of your training with you to the high-end programs.

If you use CAD professionally or your drawings are at all complex or three-dimensional, you'll want a math coprocessor chip. There is probably no other application in which the addition of an 8087 or 80287 chip can save you so much time. ■

Phillip Robinson is a BYTE contributing editor and an editor of The Architect's PC *and* Desktop Engineering News. *He can be contacted at* Desktop Engineering News, *P.O. Box 40180, Berkeley, CA 94704.*

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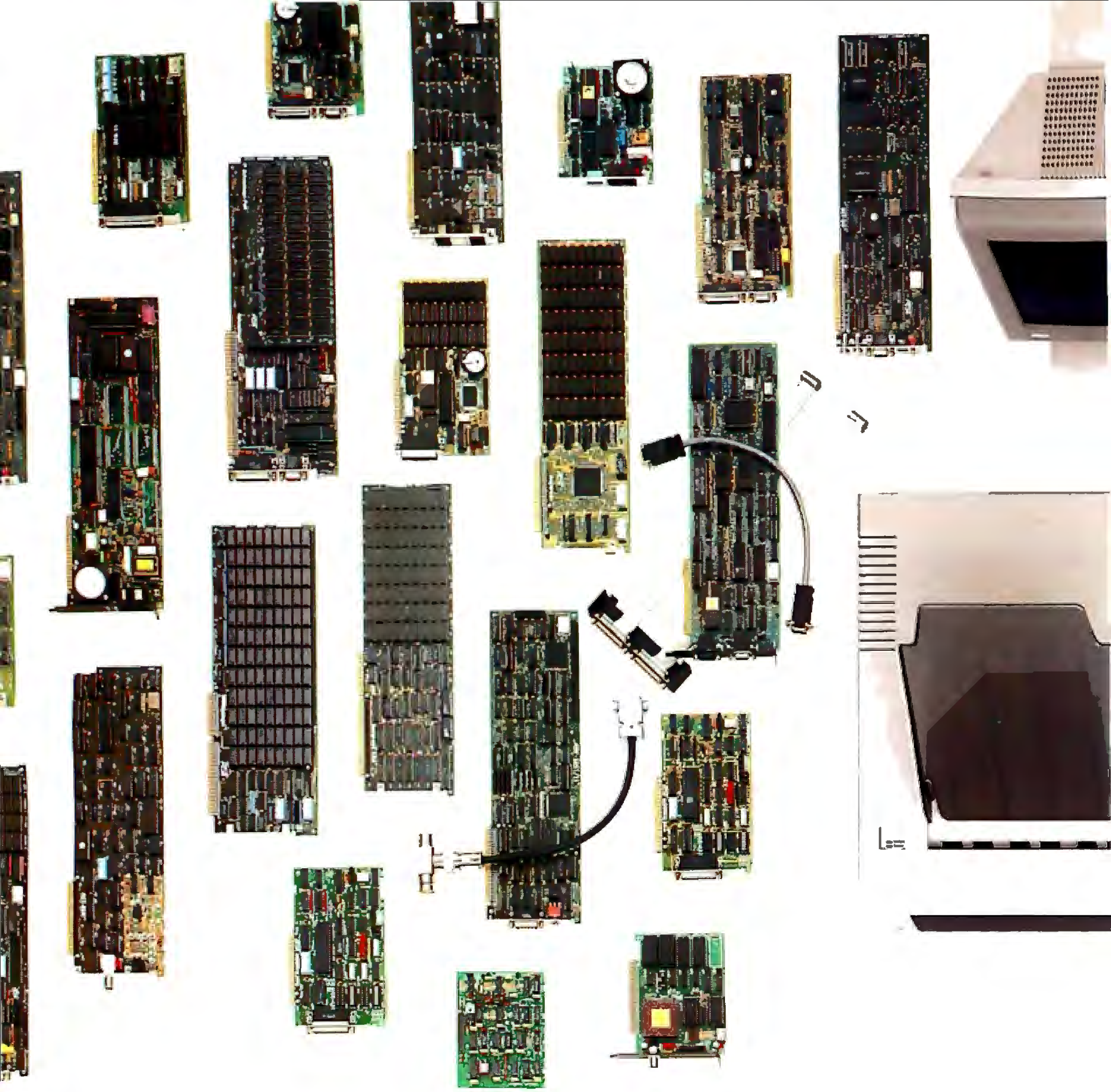

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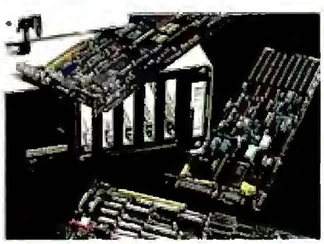

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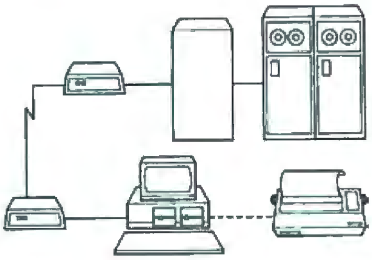

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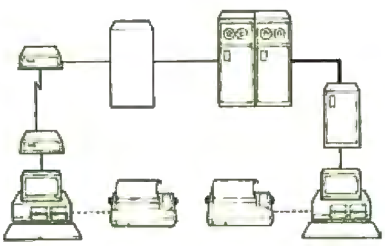

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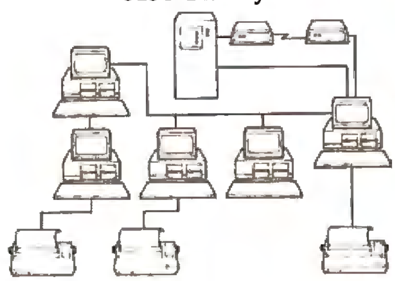

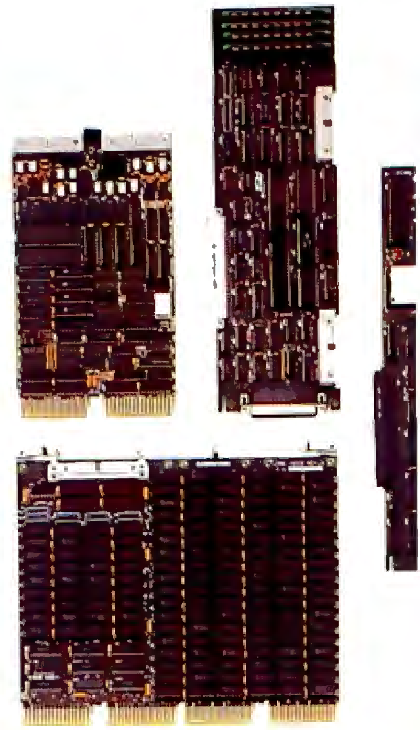

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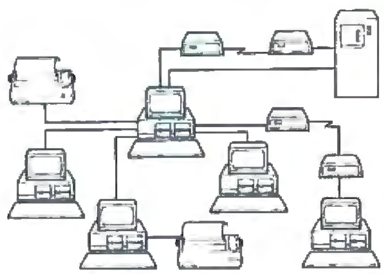

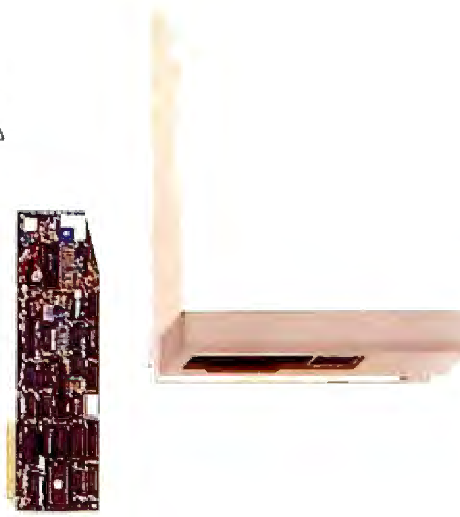

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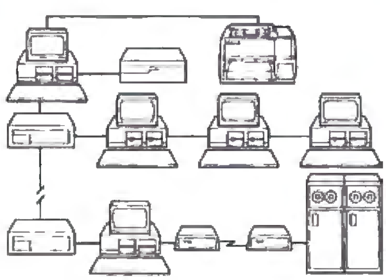

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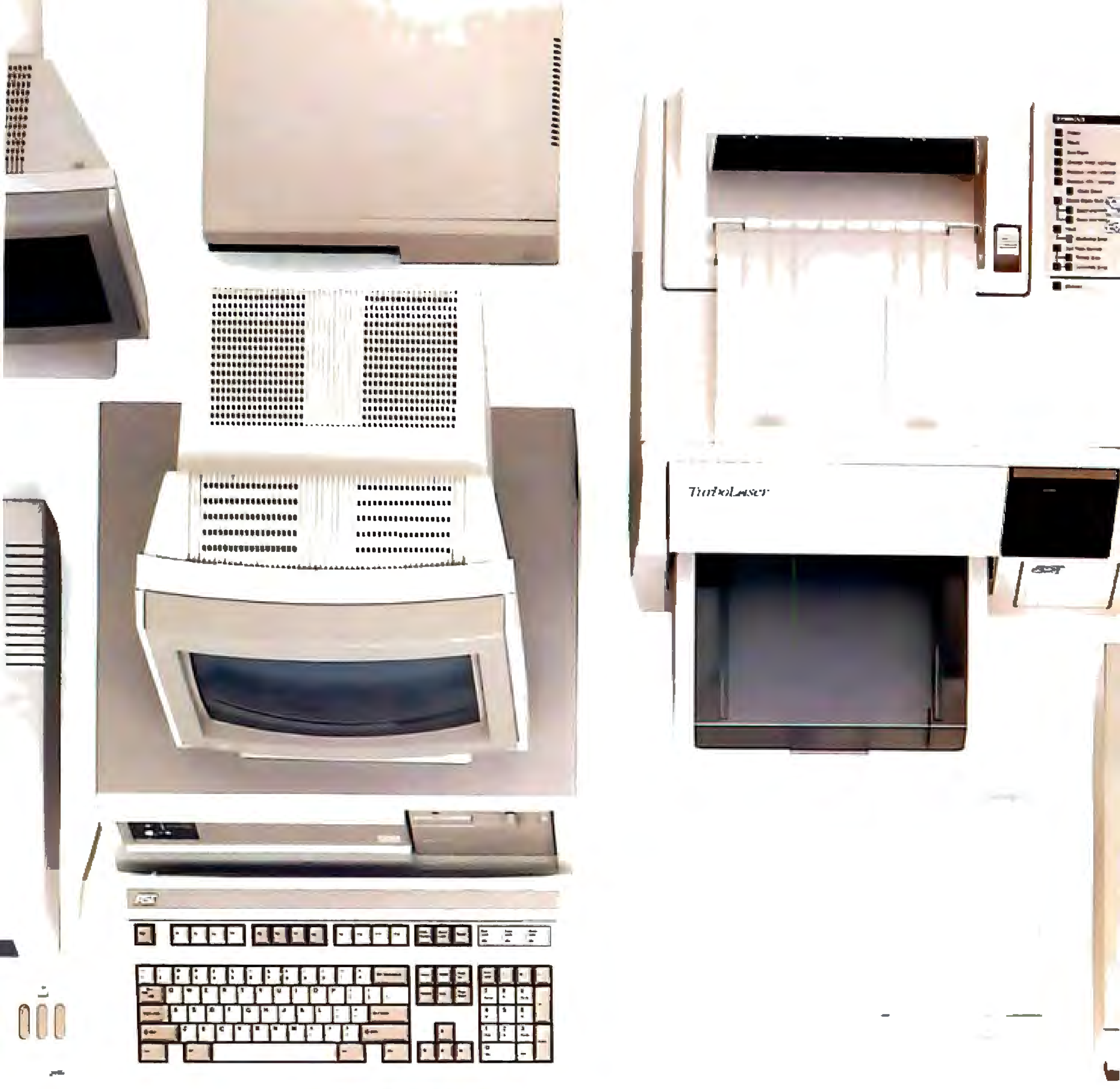

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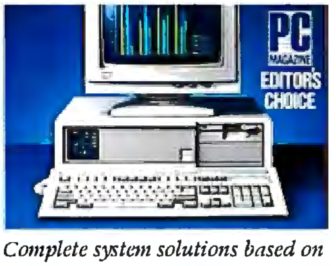

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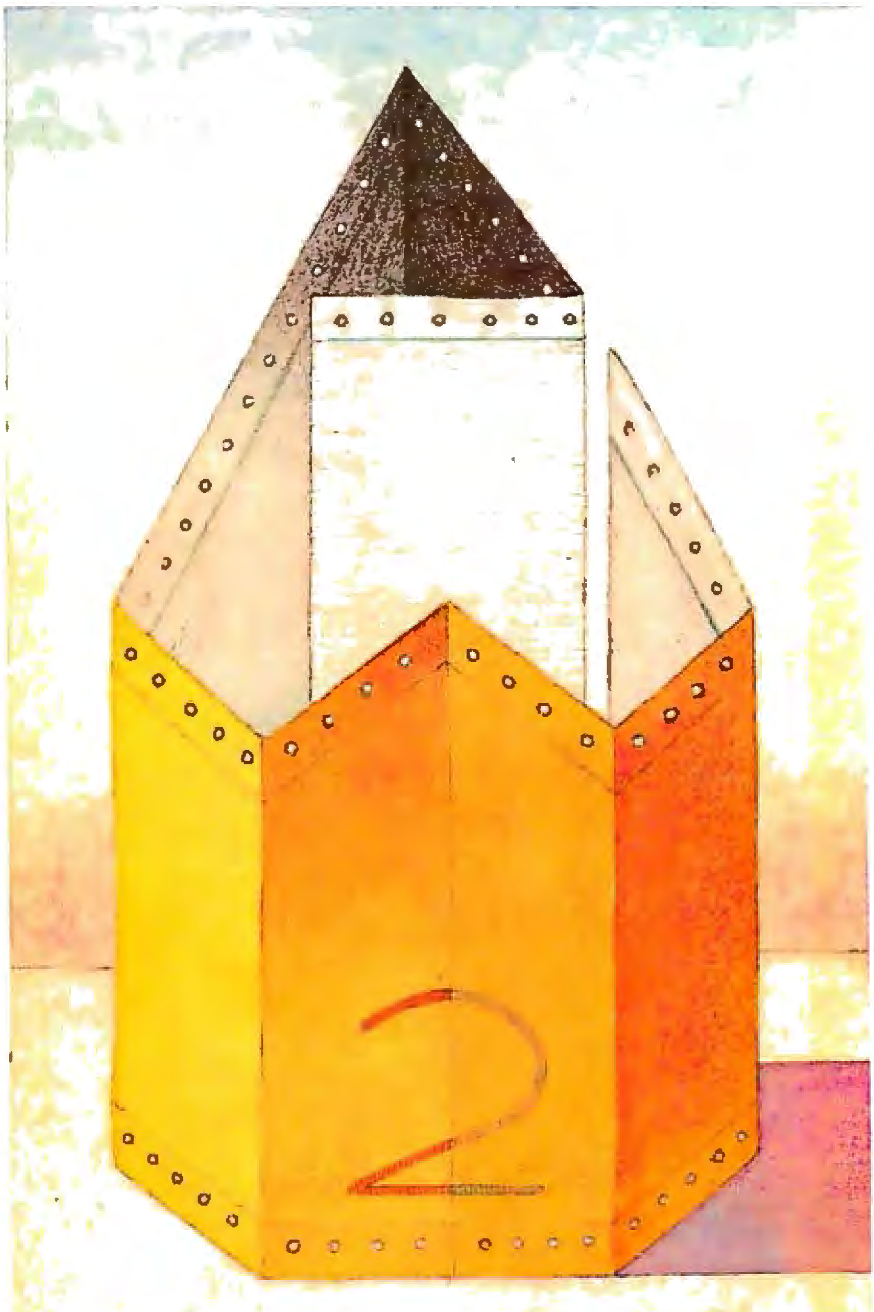

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Faster, Bigger, Better

Jerry Pournelle

Jerry tries out 386 machines, a CD-ROM, and a glorious EGA monitor

It has been quite a month: equipment of all kinds, plus dramatic new developments in technology. These are exciting times for microcomputer people: OS/2 may not be all you thought it would be, but really neat 386 systems are already here—with better to come.

We've also got the CD-ROM. I've often said this will change the world. I guarantee you that CD-ROM medical-library systems will change the medical world.

Comparing Apples and Oranges

Meanwhile, we have a *lot* of new machines and two new BASIC compilers. The obvious way to compare computers and programs is with benchmarks; but which benchmarks? A few years ago, I got unhappy with the conventional Sieve of Eratosthenes because it doesn't test enough of the things you want a computer to do. After some thought, I came up with a program to fill two matrices, multiply them together, and sum the result. That benchmark was published in the October 1982 BYTE, and a number of people have used it since.

I've thought off and on about benchmarks since then. Matrix multiplication has lots of floating-point arithmetic as well as integer counts, loops, and decisions. What it lacks is I/O, including writing to the screen; and while counting loops forces a lot of integer-decision logic, it doesn't require comparing floating-point numbers. Still, I figured the matrix benchmark program would be a good starting point, and once I got that done I could add some new features.

Alas, things were more complicated and took more time than I'd expected. I'll have to add those additional features another time; meanwhile, let's look at the compilers I used on the benchmark.

Turbo BASIC

My initial reaction to Turbo BASIC was extremely favorable, but the real test would be to write programs with it. The benchmark seemed like a natural.

My original 1982 benchmark used subroutines. Turbo BASIC has a number of features reminiscent of Pascal, including procedures, true local variables, and, most important, recursion. It improves on standard Pascal by providing static variables (these are local to a procedure but don't go away when you exit the procedure), dynamic string sizes, and all the panoply of BASIC I/O. Without doubt, you can write big programs in Turbo BASIC; and for small quick-and-dirty programs, the Turbo environment is nearly ideal. Also, there are `INCLUDE` features to make it easy to build up a library of code modules.

The Turbo BASIC editor is like the one in Turbo Pascal, or for that matter, the one in SideKick, and if you don't like the command set, you can always change it with the built-in setup routine. It takes a little time to get used to the way the compiler "zooms" in (to get rid of the command menus across the top of the screen), and I have yet to find a consistent way to make everything vanish except what my program is running, but those are minor complaints; the Turbo environment really is easy to work in.

There's another plus with Turbo BASIC: if you're a BASIC programmer and want some day to learn Pascal, you can learn all about the Borland environment with Turbo BASIC, making the transition to Pascal much easier. The bonus to that, I'm told by a Turbo C tester, is that if you've learned Turbo Pascal and want to switch to Turbo C, you're in hog heaven.

My original intent was to make use of some of Turbo BASIC's features; so instead of merely copying my benchmark from October 1982, I rewrote it to make use of procedures. Alas, I hadn't reckoned on the paucity of examples in the Turbo BASIC manual; I never did get that version to run. It would compile, but the procedures all ran as if they were separate programs with no relation to the main body.

After I gave up, I learned why. In Turbo BASIC, variables are not automatically global the way they are in most BASICs. In particular, my matrix arrays were treated in the procedures as entirely separate entities, even though I thought I was passing global arrays as parameters in the procedure calls. I'm used to variables being global unless declared inside a procedure, but in Turbo to make a procedure use a global variable, you have to explicitly use the `SHARED` (declaration) command within the procedure. None of this is clear from the manual, although you can, with patience, puzzle it out.

The reason I gave up on Turbo's procedures was that in the middle of my struggle I got a new version of Microsoft QuickBASIC. Since my benchmark can compare compilers as well as computers, it seemed reasonable to write the thing using syntax common to many kinds of BASIC, rather than using the special features of either Turbo BASIC or QuickBASIC. The result was that I ended up copying my original 1982 benchmark with almost no changes other than using double-precision numbers for the matrix elements and using names for the subroutines (see listing 1). [Editor's note: *Jerry's benchmark program, JPBENCH.BAS, is available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4. You will need a version of BASIC suitable for your*

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.

Listing 1: *Jerry's BASIC benchmark program.*

```
The BENCHMARK PROGRAM

REM A benchmark program to test machines, compilers, and
'   languages.

REM ** DECLARATIONS

DEFINT I - N
DEFINT E
DEFDBL A - C
DEFDBL S
REM Variable "start$" is a string.

REM *** CONSTANTS

ELEMENTS = 50
SUM = 0
BELL$ = CHR$(7)

REM *** DIMENSIONS

DIM A(Elements, Elements)
DIM B(Elements, Elements)
DIM C(Elements, Elements)

REM *** PROGRAM

CLS                                   'Clear the screen or it will scroll funny
Print "This is a program to fill two matrices of ";
print Elements;
print " elements, multiply them, and sum the result."
print
print "It can be used as a benchmark program to test ";
print "languages, compilers, or machines."
print
print "Written by Jerry Pournelle, May 1987."
print "Not copyrighted."

input "Start timer. Enter any character to begin. ";start$

GOSUB FillA
Print "A Filled."

GOSUB FillB
Print "B Filled"
GOSUB FillC   ' Needed because some compilers can't cope.
Print "C Filled"

GOSUB DoMultiply
Print "Multiplied"

GOSUB SumItUp
Print "Sum = ";Sum
BEEP (5)

END

REM ************* PROCEDURES **********
FillA:
 FOR i = 1 to Elements
 FOR j = 1 to Elements
       A(i,j) = i + j
     NEXT
   NEXT
RETURN   ' End FillA

FillB:
 FOR i = 1 to Elements
```

continued

computer in order to run the program.]

This compiled fine once I figured out that in Turbo BASIC, a "subroutine name" (i.e., label) must be the only thing on its line and must be followed by a colon, but when you invoke the subroutine you must not use the colon. This isn't so easy to figure, because the world "label" never appears in the Turbo index, and the discussions of the SUB and GOSUB commands give precisely one example, in tiny type, with enough remarks to bury the label. Eventually, by using the big magnifying glass that comes with the transistorized *Oxford English Dictionary*, I caught on. After that, things were simple.

Turbo BASIC gives you a number of compiler options. One, keyboard break, lets you interrupt the program. Others do stack and overflow tests. Finally, you can compile to require that an 8087 be present in the target machine. I compiled the benchmark with all options off, then did a separate version with the 8087 option on. With that done, I was ready to tackle QuickBASIC.

QuickBASIC

QuickBASIC started off in CP/M days as BASCOM, a compiler for Microsoft Interpretive BASIC. Since then it has grown in spurts and starts. By one of those odd coincidences that make you believe in statistics, QuickBASIC got a drastic overhaul after Borland announced (but hadn't yet shipped) Turbo BASIC; about then, Microsoft added an integral editor. It was upgraded again, to version 3.0, just after Borland began shipping Turbo BASIC.

As with Turbo BASIC, you can still create a QuickBASIC program with your favorite programming editor (I prefer BRIEF for the PC; it's almost as good as WordMaster was for CP/M), but you'll probably be better off using the built-in editor; you'll certainly use it while debugging. As probably comes as no surprise, the QuickBASIC editor has similarities to Microsoft Word and is designed for use with a mouse. I'm not always fond of computer rodentia, but I find the mouse definitely useful here. It doesn't always do what I expect, but that's due to my unfamiliarity with it. I think the Turbo environment may be marginally easier to use than QuickBASIC's, but either is a lot more than good enough.

The QuickBASIC manual is thicker than Turbo's. That's in part due to larger type. There are also more examples, and the index is a little better, although "label" isn't in it either, except as a reference to a search command in the editor. In general, though, the QuickBASIC

continued

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```
            FOR j = 1 to Elements
              B(i,j) = (i + j) / j
            NEXT
          NEXT
RETURN    'End FillB

FillC:
        FOR i = i = 1 to Elements
          FOR j = 1 to Elements
            C(i,j) = 0
          NEXT
        NEXT
RETURN    ' End FillC

DoMultiply:
        FOR i = 1 to Elements
          FOR j = 1 to Elements
            FOR k = 1 to Elements
              C(i,j) = C(i,j) + A(i,k) * B(k,j)
            NEXT
          NEXT
        NEXT
RETURN    ' End DoMultiply

SumItUp:
        FOR i = 1 to Elements
          FOR j = 1 to Elements
            SUM = SUM + C(i,j)
          NEXT
        NEXT
RETURN    ' End SumItUp

Print "ESAD!" ' Shouldn't be able to get here.
END
```

manual is clearer than Turbo's. On the other hand, Turbo BASIC comes with more example source code on disk.

When I wrote my accounting program in 1979, I did most of it in compiled CBASIC because it was so much faster than Microsoft Interpretive BASIC. Later I was in a hurry to add some complex file-handling programs to the package, and CBASIC was just too slow an environment to work in; so I wrote and debugged them in regular BASIC and compiled them with BASCOM. I haven't used QuickBASIC much since.

Compiled BASIC always was a bit different from interpreted. Compiled CBASIC had a number of control structures; getting them all into their compiler took Microsoft a long time. Eventually they did.

You can write quite complex stuff with QuickBASIC. Bruce Tonkin, of TNT Software, wrote his word processor MyWord! in QuickBASIC. MyWord! is fast, easy to use, and, with its tons of features, has as much bang for the buck as any word processor I know. Tonkin also wrote a pretty good low-cost database.

My editor/publisher Jim Baen developed a thing called QuickSCREEN that tacks onto QuickBASIC programs and makes screen management a snap. There are other third-party enhancements, while over the years Microsoft has added enough features to make QuickBASIC quite a different (and much better) language from the old BASCOM.

With version 3.0 they went even further, adding the splendid Microsoft debugger, the one that made Microsoft C the king of the C compilers. They changed the variable handling to support IEEE math format for floating-point numbers. This wasn't easy, because there's a lot of old Microsoft code in the old Microsoft binary format out there.

They finally solved the problem by releasing two completely different compilers and library sets. The compiler named QB uses the old BASICA-compatible Microsoft binary format floating-point numbers; QB87 is in IEEE format and supports the 8087 and 80287 math chips. This makes a *dramatic* difference in computation speed. If you have a math chip and your code supports that, compiling with the IEEE format speeds you up a lot; if you run an IEEE-format program on a machine *without* a math chip, however, it will run even slower than if you used the binary compiler.

Also, QB87 will not run on a machine that does not have an 8087. That is, the code that QB87 generates will run, but you cannot compile code in QB87 on a machine that doesn't have the 8087 or 80287 chip. Turbo BASIC doesn't do that to you.

Other new features in QuickBASIC 3.0 include DO (WHILE and UNTIL) loops, SELECT CASE, and constants. The easy way to sum it up is that if you liked QuickBASIC 2.0, you'll *love* 3.0.

Up to now, QuickBASIC had no real rivals; now, however, there's Turbo BASIC, with recursion and other features that QuickBASIC lacks.

They're both pretty good; more comparisons next month.

Benchmark Variations

Getting my benchmark program into QuickBASIC was a snap: I merely copied the source code from the Turbo BASIC subdirectory, renamed it, and compiled it. The first time I did that I was dropped into the editor: in Turbo BASIC, you use the syntax BEEP (5) to issue five beeps when the program is done; QuickBASIC makes you issue five different BEEP statements. Once I fixed that, the program compiled fine.

Turbo BASIC produces stand-alone code; each program is automatically linked as you compile, so that the result is an executable (.EXE) file that runs by itself. You can compile so as to force the target machine to have an 8087, 80287, or 80387 math chip. If you do, you'd better have one: a bug that Borland says they'll fix in the next release locks up the machine if you try running an 8087-compiled program on a machine with no math chip. I did two separate Turbo BASIC compilations, each of them with debug and all other options turned off: TBEN runs without a math chip, and TBEN87 requires a math chip.

QuickBASIC has a bunch of options. Besides debug and error handling, you can compile for best program speed or minimum program size; and you can compile to use IEEE floating-point format, and thus support the 8087 and 80287 math chips, or Microsoft binary format. After some thought I did them all, with all debug and error handling turned off: QBEN is in binary format, optimized for speed; QBENSL is in binary format, optimized for code size; QBEN87 is in IEEE format, optimized for speed; and QBENSL87 is in IEEE format, optimized for code size.

Unlike Turbo BASIC, QuickBASIC 3.0 offers another option: you can produce stand-alone code, as Turbo does; or you can compile to make use of the run-time programs BRUN30 and BRUN3087 (for systems with and without a math coprocessor, respectively) supplied with QuickBASIC. If you do that, you save the time it takes to link the programs; and

continued

The Kaypro 386 is built as you'd expect a Kaypro to be built. Whereas the Zenith Z-248 reminds you of an Alfa Romeo, the Kaypro is a Mack truck.

your actual program is quite small. (On the other hand, you have to have the specified BRUN program on your disk.)

I compiled all the above programs to work with BRUN and also made standalone programs that were optimized for code size in binary format (QBENB) and IEEE format (QBENB87). I suppose I could have done the smaller "slow" versions of those, too, but I figured enough was enough. Surely I had enough programs to do benchmark tests.

Getting Started

I've presented these benchmark results in table 1, but some of the tests are worth individual discussion.

I developed and compiled the benchmarks on Zelda, the Zenith Z-248 AT compatible. When I began these tests, there was no math chip in the Z-248. About halfway through, Intel sent me a 10-megahertz 80287 math coprocessor, which I immediately put in the Z-248. If that hadn't happened, I probably wouldn't have discovered something about Turbo BASIC, namely, that even if you compile for "no 8087," it will make use of the math chip if it finds one. Thus, the two lines on the chart for Zelda the Z-248, with and without math chips (see table 1).

Other machines tried were the CompuAdd Standard 286-II AT clone (see last month's column) with Cheetah 386 card; Lucy Van Pelt, the original IBM PC; Zebediah, the Zenith Z-181 portable; Attila the Honey, the AT&T 6300 Plus; and Fast Kat, the Kaypro 386. You haven't met Fast Kat yet.

A First Look at Fast Kat

You'll recall that Big Kat, the Kaypro 286i that was the main machine here for well over a year, went off to college with my number two son. Big Kat is home for summer vacation now, still running, and is the main downstairs machine for the boys, visiting assistants, and others who need a machine. He's tied into the CompuPro ARCNET, and he does yeoman service.

His big brother, a Kaypro 386, arrived while we were away in New York; between deadlines and the flu, he just barely got uncrated in time for these tests. I'm glad he did. That machine is speedy; we've named him Fast Kat, and he may become the number one computer at Chaos Manor.

The Kaypro 386 is built the way you expect a Kaypro to be built. Whereas the Zenith Z-248 reminds you of an Alfa Romeo, the Kaypro is a Mack truck. The case is rugged heavy metal. Even the keyboard is rugged heavy metal. The only plastic case on the Kaypro setup is on the Korean-made EGA monitor.

The keyboard is in the new IBM style that has 12 function keys at the top. I like it all right, but I really prefer the feel of the DataDesk Turbo-101, and I'll soon install one on Fast Kat.

There was one big disappointment with Fast Kat: in the old days, when Kaypro sent a machine, they also sent very complete technical manuals. This one, alas, comes with a manual that's about good enough to let you get the machine running, but doesn't tell much more.

When we opened the machine, we found it has a built-in serial and parallel port, so you don't have to use up any slots. If there's a place for a math chip, I can't find it; it would have to be hidden under the hard disk drive. The manual says nothing about the subject. Fast Kat came with an EGA board and a Kaypro-labeled, Korean-made EGA color monitor. The colors are sharp and crisp, and letters are well-formed. As you'll see below, I'm a bit spoiled with my Megatrend monitor, but this one is as good as any other EGA monitor we have.

Powering up the Kaypro 386 was no more than turning it on. The machine says it has 512K bytes of main memory and 2048K bytes of extended memory. A story goes with that. When we looked inside Fast Kat, we found that the motherboard is made by Intel. Intel, it turns out, had real problems configuring the 386 system for 640K bytes, so they left it at 512K. That means that people who buy a 386 to run something like AutoCAD at full speed find that just when they need the fast 32-bit memory, they fall off the 512K-byte cliff.

On a 286 you would simply backfill from an extended-memory board, and you can do that with the 386, but it's not quite so simple. Fast Kat has a 2048K-byte Kaypro memory board of 32-bit memory that plugs into a proprietary Kaypro 32-bit bus slot. There are two of those; the rest of the slots are standard IBM PC AT-compatible slots. Alas, the Phoenix BIOS doesn't know how to make use of that fast memory to backfill the space between 512K and 640K bytes.

That's all right: Quarterdeck's QEMM 386 Expanded Memory Manager *does* know how to do that. All you have to do is have `DEVICE = QEMM.SYS` as the *very first* item in your CONFIG.SYS file (it won't work if there's anything ahead of it), and QEMM will backfill for you. I don't know of any other program that will do that for a Kaypro. Of course, Compaq has CEMM.SYS to do the same thing for Compaq machines.

Once you've installed QEMM.SYS, you must leave the Kaypro Setup program thinking you have only 512K bytes of system memory; if you don't, the Phoenix BIOS will beep at you. Then power the system up, and you have got one *fast* machine. I don't know how it benchmarks against a Compaq 386, but Fast Kat is

Table 1: *Results of various computers running the benchmark program as compiled by Turbo Basic and QuickBASIC. See the text for a description of the tests.*

Computer	TBEN	QBEN	QBENSL	QBENB
Code size (bytes)	23,890	75,400*	75,240*	32,936
Zenith Z-248	1:23	1:02	1:25	—
Zenith Z-248 w/ 80287	23	1:02	1:25	43
CompuAdd w/ Cheetah 386 card	1:56	1:05	1:27	58
CompuAdd w/ Cheetah 386 card (virtual mode)	2:58	1:06	2:59	1:00
Kaypro 386	50	32	43	29
Kaypro 386 (virtual mode)	1:16	32	1:23	26
AT&T 6300 Plus	2:00	WR	WR	1:00
Zenith Z-181	8:02	4:20	5:39	3:48
IBM PC	7:44	4:08	—	3:38

*Total includes 70,680K bytes for BRUN30
WR stands for won't run
(You don't save much code size for the speed loss.—JEP)

certainly the fastest machine in Chaos Manor just now.

Fast Kat came with a Priam 40-megabyte hard disk. This thing is not only about the fastest hard disk in captivity, it's also one of the most rugged. It "automagically" goes to a landing position on power-down; none of this SHIP (a utility that moves the hard disk to a landing area) for Fast Kat.

Of course, DOS is too stupid to find more than 32 megabytes of a hard disk. Our Kaypro 386 came with SpeedStor, a hard disk integration and diagnostics program and book. SpeedStor tells you how to install and partition hard disks, and I'm quite impressed with it. Alas, we've been so rushed here that we've had little chance to repartition Fast Kat's disk. I've got, I think, 20 megabytes as the C drive, and Fast Kat can't find the rest of it. This will change; the SpeedStor manual is very complete, and it won't take us long once things slow down.

Meanwhile, Fast Kat is set up and ready. We have an AST RAMpage AT board, an Intel Above Board, and a Cheetah board; one or more may be used to extend his memory above the 2.5 megabytes he already has; we'll see. The reason we'd do that is Quarterdeck's DESQview 2.0, which, with QEMM, will let us run Fast Kat as if he were several 640K-byte machines. Our 2.5 megabytes will give us three virtual computers with a bit left over. That may be enough; on the other hand, I find that there's *never* enough memory. We'll see.

I haven't physically moved him to the post by my desk yet, but it's pretty certain that Fast Kat will replace Zelda as the main machine in my office. Of course, it won't be long before we have a Zenith 386 to compare him to. I love the way these companies keep improving my life.

Back to the Bench

Once I had the benchmark, it was time to try it. That wasn't quite as simple as it sounds. For example: the benchmark programs were compiled on the Z-248. Like all AT machines, the Z-248 has a high-density floppy disk drive. It's very easy to transfer the benchmark program from one AT to another—but not so simple to get it into Lucy Van Pelt, the ancient IBM PC. Lucy can't read the output of high-density drives.

It's easier for us than most. All our machines are connected through the CompuPro ARCNET system. Once I had the benchmarks written and compiled, I put them over into the PC format partition of the Golem's hard disk—the Golem is our CompuPro S-100 286 with a Z80 slave processor—after which they can be

continued

accessed by any of the other machines on the network.

Of course, when I say our machines are connected to the network, I don't really mean it. What I mean is that we have the network hardware and software, the machines, and the wire; alas, we haven't yet permanently strung the cables, so when I set up the network there are cables all over the floor. The whole house, upstairs and down, looks like a giant spider has been at it. I've promised Mrs. Pournelle that I'll get the wires permanently strung through the crawl spaces Real Soon Now.

Network Annoyances

There's only one trouble with the network: when we try to log on to it with the Z-248 after the machine has been running for a long time, sometimes it just won't do it. The solution is simple enough: turn Zelda off for a moment. The CompuPro ARCNET PC board gets its own address information on power-up; and when that's refreshed, there's no problem. Logging on is simple, and once logged on, the network has never gone down, even after several days of continuous use.

Another problem with that: Zelda has a Cheetah Combo board for expanded memory; MS-DOS's VDISK.SYS turns that into a RAM disk, whereupon a program called Above Disc takes a portion of that RAM disk, partitions it off, and uses it as a swapping area for memory-resident and other programs that know how to use Lotus/Microsoft/Intel expanded memory. (Expanded memory = "can be used by PC; Extended = "needs an AT.") Ready! is a memory-resident program that stuffs itself into the swap file, saving me a lot of memory; but, alas, sometimes Ready! doesn't seem able to find the extended memory.

The remedy to that is odd: you have to change the order in which Ready! and the CompuPro network software are invoked. That gets Ready! up where it belongs, and the network working; but if I bring in any more memory-resident programs in that configuration, I get other problems. Luckily, though, if I do that, then go *back* to my regular order (Above Disc first; network software second; Ready! third; Logitech mouse next; then SuperKey and SideKick) and reboot again, Ready! finds the extended memory, the network finds itself, and all is well. I never have figured out why that works, but it does.

This means that if I have to reset, I might be several minutes reconfiguring until things are the way I want, with Ready! in its proper place and the network on. That's fine for a few days—until the modem refuses to hang up.

Every now and then, for no reason I understand, every modem I have ever used, including the OmniTel 2400-which is usually quiet, efficient, fast, and has the lowest error rate with noisy lines of any modem I've ever seen—will refuse to hang up the phone. I can send it "BYE" until I'm blue in the face, but it won't believe me. The only remedy is to turn the machine off.

Check Your Math Chip

Lucy Van Pelt *never* gives any trouble logging on to the network, so it was simple enough to transfer the benchmarks downstairs to her. In fact, I didn't even have to transfer them: by mapping the network so that Lucy thinks her drive F is the Golem's C drive, she'll run programs stored on the Golem.

I sat down at Lucy's keyboard, got out my stopwatch, did F:TBEN, and waited. The header appeared. I started the benchmark and stopwatch. After a while, the program announced that it had filled the matrices; then that it had multiplied them; then it announced `Sum =`. Then it stopped. I waited for it to give the sum and end with five beeps.

And waited. And waited. Nothing happened. Lucy was hung up completely.

Reset. Log back on to the network. This time copy the programs off onto a floppy disk in Lucy's B drive. Now try to run TBEN.

Same result. The network was working fine. I tested the program by putting Lucy's disk into another machine and invoking TBEN; it worked splendidly on every machine in the house. The Turbo BASIC manual says you need a PC, XT, AT, or close compatible and DOS 2.0 or higher. I had that, but no matter. Every time I tried that program in Lucy, she went off to the land of lost bits. It was clearly time to call Borland.

The Borland people couldn't understand it. Meanwhile, a day or so after I'd run the benchmark on the Z-248, I installed the 10-MHz 80287 in Zelda; and when I brought Lucy's disk up to test whether I had a good copy of the program, I found that not only did it run, but it ran a *lot* faster. Programs generated by Turbo BASIC test for an 8087 and use it if they find one.

Then I brought down QBEN, the Microsoft version of the benchmark. Lucy ran that fine. Then the Borland people suggested their program might be

continued

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Inquiry 244

thinking there was an 8087 in the machine when there wasn't one. I was about to agree when I remembered that years ago we'd put an 8087 into Lucy Van Pelt. It should still be there.

I brought down QBEN87. It ran fine—except that when it was done, it had the wrong checksum. I tried that twice more, with the same result. The program ran to completion but had the wrong answer.

By then, of course, I knew what the situation was. The 8087 was working just well enough to let the programs believe there was one in the system; but not well enough to let the Borland program run properly. The Microsoft code generator was more tolerant and let the program run—but give the wrong answer.

Once I understood that, I removed the math chip. Everything worked fine.

The moral of the story is that if you have a system with a math chip, you may want to check it against a known problem like my benchmark every now and then. That 8087 has been in Lucy for at least five years. We've never had any indication that anything was wrong until I tried my benchmark program. Fortunately, Lucy Van Pelt is mostly used as a data-entry device for Q&A files; she's too slow for spreadsheets. I don't think we've got any significant wrong answers—but we easily could have.

Attila's Blues

The next surprise came when I tried to run the QBEN programs on the AT&T 6300 Plus. The first time, I got a message saying "Incorrect version of BRUN30"; on all subsequent attempts, I got a "System Error" message and had to reset the machine.

So far as I can tell, the first release version of BRUN30 simply will not work on my AT&T 6300 Plus. Understand: I can't say that everyone will have problems with QuickBASIC 3.0 on the AT&T 6300 Plus. This is just my experience so far.

However, the TBEN and QBENB stand-alone programs not only ran on the 6300 Plus, but in times comparable to the Cheetah 386.

I haven't yet got a math chip installed in the 6300 Plus. The Bell Labs people tell me the odd network of stuff I found in the 80287's slot aboard the 6300 Plus (see last month's column) is designed to tell certain buggy versions of Lotus 1-2-3 that there is no math chip; I can pull it all out without hurting anything. I have a 6-MHz 80287 chip I intend to put in there.

DESQview

DESQview is a program that lets you run multiple applications simultaneously. I wasn't particularly impressed by the IBM PC version, and I wasn't all that happy with it for AT compatibles—although I hasten to add that I didn't take a lot of time to get familiar with it, and a lot of people I respect really like it.

The new DESQview, running on a 386, is a different story.

DESQview 2.0, with the QEMM memory manager, can in theory, at least, do about as much for you as OS/2 (aka Advanced DOS or ADOS); not only that, you can run Microsoft Windows as a window within DESQview. I've done it.

Of course, we can't be sure what OS/2 will do because we don't have it yet; when we do get it, it won't be in 386 native code and won't make much use of the 386's special features. By that time, I suspect there will be CompuPro, Compaq, and Cheetah 386 machines that can eat the IBM systems on speed; but leave that. What we do know right now is that there is awesome potential in 386 systems with DESQview, and you can have that immediately.

There are problems. DESQview forces 386 machines to operate in the "virtual 8086 mode." That wouldn't be bad except that nearly everyone's compilers—

continued

Table 2: *Results of various computers running the benchmark program compiled with 8087 optimization. See the text for a description of the tests.*

Computer	TBEN87	QBEN87	QBENSL87	QBENB87
Code size (bytes)	23,890	80,800**	80,656**	32,766
Zenith Z-248 w/ 80287	20	31	40	30
CompuAdd w/ Cheetah 386 card and 80387	17	27	37.5	27
CompuAdd w/ Cheetah 386 card and 80387 (virtual mode)	29.5	27	1:21	27
Kaypro 386 w/ 80387	9.5	14	20	14
Kaypro 386 w/ 80387 (virtual mode)	15	13	38	13
IBM PC w/ 8087	47	1:09	1:52	1:09

**Total includes 76,112K bytes for BRUN3087

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To y there a umero o-computer statistics softv packages to consider.

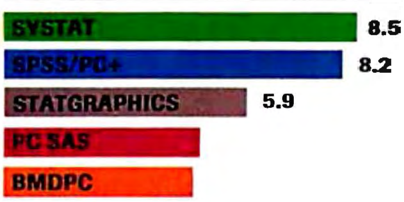
But, in the considered opinion of many expe s, there is one at is clearly etter

rated.

In its recent review of t e leading microcomputer statistics programs, *InfoWorld* concludes that Systat™ Version 3.0 is "unrivaled in performance", "tops in umber crunc ng power nd nfailingly accurate."

And *InfoWorld* doesn't stop ere, but goes on to rank Systat as the Numbe ackage of the group.

In doing so, they aren't alone. ery published independent mparative review rates Systat the top of the list.



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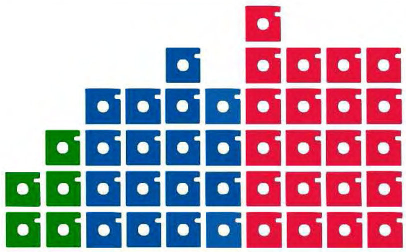

Although more comprehensive, Systat requires less than ½ the commands and has ½ the bulk of competitive programs. Compare its 5 disks to 17 for SPSS/PC+ and 21 for PC SAS!

n merous reviews and technical conference proceedings consistently prove Systat to be the most accurate statistical package available.

Is ease of operation important? Systat operates on less than ½ the commands of its two largest competitors, ith less than ½ the bulk. According to *InfoWorld*, "Systat's commands are terse, and a few keystrokes will do amazing things."

Is cost important? Systat costs less than any other major package: less than ½ the price of the comparably equipped PC SAS or SPSS/PC+.

Truly interactive.

Unlike its major competitors, Systat has *not* ported some 20-year-old code from a mainframe program. Written specifically for microcomputers, Systat Version 3.0 uses an incredibly small amount of disk space: only 1.4 megabytes versus their 5 to 10 megabytes.

What's more, the package is genuinely interactive, freeing you from rigid command protocols. In doing so, Systat allows you to approach statistical problems more intelligently: letting you work the way you think instead of forcing you to think the way it works.

Next to this, the alternatives to Systat don't look very bright.

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Systat. Intelligent statistics.

The Cheetah 386 with DESQview could be the system of the year, even better than some of the new IBM ones.

including Microsoft's—generate code that uses interrupts for things like determining if there's a math chip present or saving code size; and that slows things down significantly in virtual mode, as you'll see from the benclunark charts (see table 2).

DESQview is powerful, which means it's complicated; you have to know the program well before you start getting big advantages, and although the 2.0 manual is greatly improved over the old one, learning DESQview is a nontrivial task. Also, if you don't know the program well, you'll hang the machine more often than you like. I've had to reset a dozen times today.

Still, an hour ago I was logged on to BIX with Crosstalk under DESQview; and while in Crosstalk, I opened the Grolier's Encyclopedia CD-ROM in another window. I was able to look up all kinds of stuff while still connected to BIX. I haven't figured out how to cut and paste to transfer items from one window to another, but I'm sure that there has to be a way.

If you've got a fast AT and any sense of adventure at all, get DESQview 2.0. It's no harder to learn than the original Adventure game, and when you've learned it you have a powerful tool. Recommended, provided you'll take the time to learn it properly.

Cheetah

Cheetah International is one of the most impressive small companies I've ever run across. They understand the IBM bus better than anyone, including IBM and Intel. They know memory backward and forward.

The following is my personal opinion, based on previously reliable sources.

Cheetah thoroughly understands the new IBM bus; indeed, by the time you read this, they'll have a gate-array chip out that anyone can buy: put it on a card you've designed, and you can plug that card into the new IBM bus. You won't have to figure out all that hairy logic. In other words, Cheetah is advancing Clone Day by six months to a year.

As I write this, Cheetah makes the only zero-wait-state memory boards in the business; the only ones that will work with the Z-248 at full speed. Up to now, that has made Cheetah boards expensive. They need 70-nanosecond memory chips, as opposed to the 120-ns or even 150-ns chips most board makers use.

The good news is that Cheetah recently concluded a deal to buy 70-ns chips for about what others are paying for 120-ns chips; the result will be a dramatic reduction in price.

We have a Cheetah Adapter/386 board installed in a CompuAdd AT clone. As you can see from the benchmarks, it's a pretty good system; given what it costs, it's darned good.

However, it's only an interim solution. By the time you read this, you'll be able to buy a Cheetah 386 motherboard. Unlike the Intel motherboard, the Cheetah motherboard will have a full megabyte of fast 32-bit memory. You'll also be able to add Cheetah boards in pairs to extend that 32-bit memory as far as you like. They intend to sell that board—either as a kit to install in your AT or compatible or as a system—for AT clone prices, dramatically lower than anything I've seen with comparable speed and power.

The result should be awesome. The new Cheetah 386 with DESQview could be the system of the year; indeed, a better system than some of the new IBM machines. Before you look at anything else, check with Cheetah. You may be glad you did.

Megatrend

I recently gave up on glasses: I went to the optometrist and got a pair of "computer glasses"; these have my normal reading bifocal element, but the main portion of the glasses focuses at 28 inches; just the distance I keep my head from the screen. The result is wonderful.

No sooner had I done that than Intecolor sent me their 19-inch Megatrend EGA monitor. This thing is wonderful. The monitor sits on its own swivel base. The color is crisp and clear. The letters are perfectly formed, and you can read text from across the room. EGA Paint from RIX SoftWorks with the Logitech Bus Mouse makes startlingly beautiful pictures.

Most people who visit think I have a Sun workstation, not just an EGA moni-

continued

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Ogre $39.95
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QuickBASIC 3.0 .... $99
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Jerry Pournelle, 'A User's View,' InfoWorld

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tor on a PC AT. Of course, it's the size of a great blue whale: that high resolution takes a *lot* of electronics. So it goes.

The Megatrend isn't cheap, but then good working tools aren't cheap. If you sit at a console all day, as I do, you'll save the cost in eyestrain alone. I can't praise this thing enough. I won't have any trouble writing books. Whenever my eyes get at all tired, I can switch both background and text colors. I'm having trouble coming up with superlatives. I love it.

EGA plus Intecolor's Megatrend has, I suspect, ended my complaints about eye problems forever. Hallelujah.

Micromedex

A year or so ago, I said "CD-ROM will change the world," and Microsoft has been using that quote on their CD-ROM books ever since.

I meant every word of it; and comes now Micromedex to prove it. What they have is a complete clinical information library on CD-ROM. They also sell a Hitachi CD-ROM reader to go with it. They have to do that because CD-ROM is in a primitive state, with several different CD-ROM formats. With luck that will change.

Installation is simple. The system comes with a controller card that you drop into your computer. Use the supplied cable to connect the card to the player. Take the three disks of retrieval software, put the first disk into the A drive, and type `INSTALL`.

From there on, everything is automatic. The retrieval software creates a subdirectory and installs itself on your hard disk (which you will need to run this software). Now put the CD-ROM disk into the player and invoke the program.

The result is a full medical library right there on your screen. There's information on drug dosages; poisoning; new drugs; pediatric care; a whole plethora of stuff, all in living color (I presume it would work on a monochrome monitor, but the color makes it a lot easier to use). It's really spectacular on the Intecolor Megatrend.

After Mrs. Pournelle saw it, she had to have it: she wanted to look up the information on reading and learning disorders, as well as hyperactivity and some drug effects. There was nothing for it but to take the reader out of Zelda and install it on Attila the Honey, her AT&T 6300 Plus. That turned out to be no more difficult than putting it on the Z-248. The AT&T 6300 Plus has the AT&T brand of CGA rather than EGA; but it's hard to tell the Micromedex output on the 6300 Plus from the same on a standard-size EGA (except for my Megatrend; nothing can match that!).

The amount of information on this system is staggering. We haven't begun to read it all. There are summaries and abstracts of journal articles; and in every case the authority for the information is clearly given.

The value of this system is obvious. I don't care how good your memory is, it can't hurt to check your information against the latest sources—and Micromedex revises this *quarterly*. I suppose one might go directly to the books and journals, but that's a lot of trouble. You'd have to look up the information even if you kept all those books on your shelves. With the Micromedex CD-ROM system, it's painless and nearly instantaneous.

I'll make a flat prediction: within five years, there will not be a practicing physician in the United States who doesn't have some sort of CD-ROM reference library system.

Clearly, I'm not competent to evaluate the medical information Micromedex presents. I can say that it comes from standard sources, all of which are cited, and that it's fascinating to read through; Micromedex has done a marvelous job of digesting.

I urge everyone in medicine, whether in school, internship, or practice, to look at the Micromedex system. You may discover you can't live without it.

Winding Down

I'm out of space, and there's still a ton of stuff to report, like the Mace Utilities (wonderful), Logitech's Bus Mouse (best mouse I ever saw), Golden Bow's VMAP and VOPT disk organizers (indispensable), and a huge flood of new software. It will have to wait until next month.

The game of the month would have been Ogre from Origin Systems, except that they used a dumb copy-protection scheme. I don't mind copy protection for games, but if you transfer the game to hard disk and try to play without putting their key disk in the A drive, it hangs your system so that you must reset; and that deserves a big FOO.

Next week people from Quarterdeck, Cheetah, and Intel are coming over. We also have a new phone-answering machine that records people's messages on your hard disk. It looks like another big column next month. ■

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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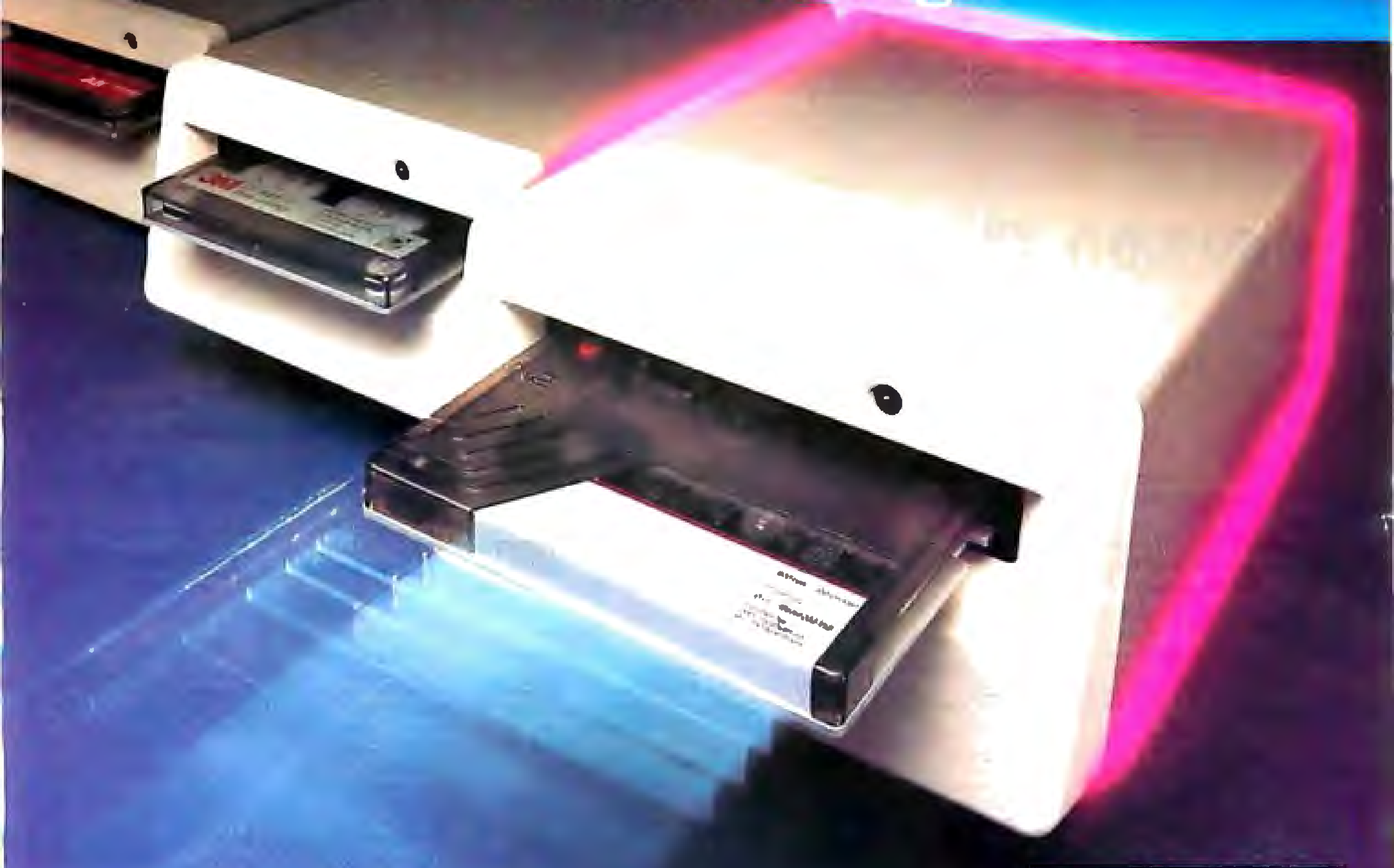

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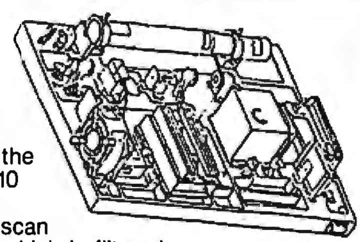

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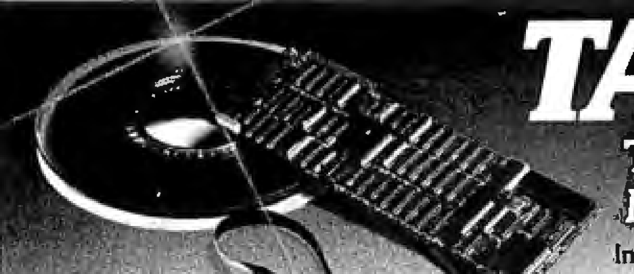

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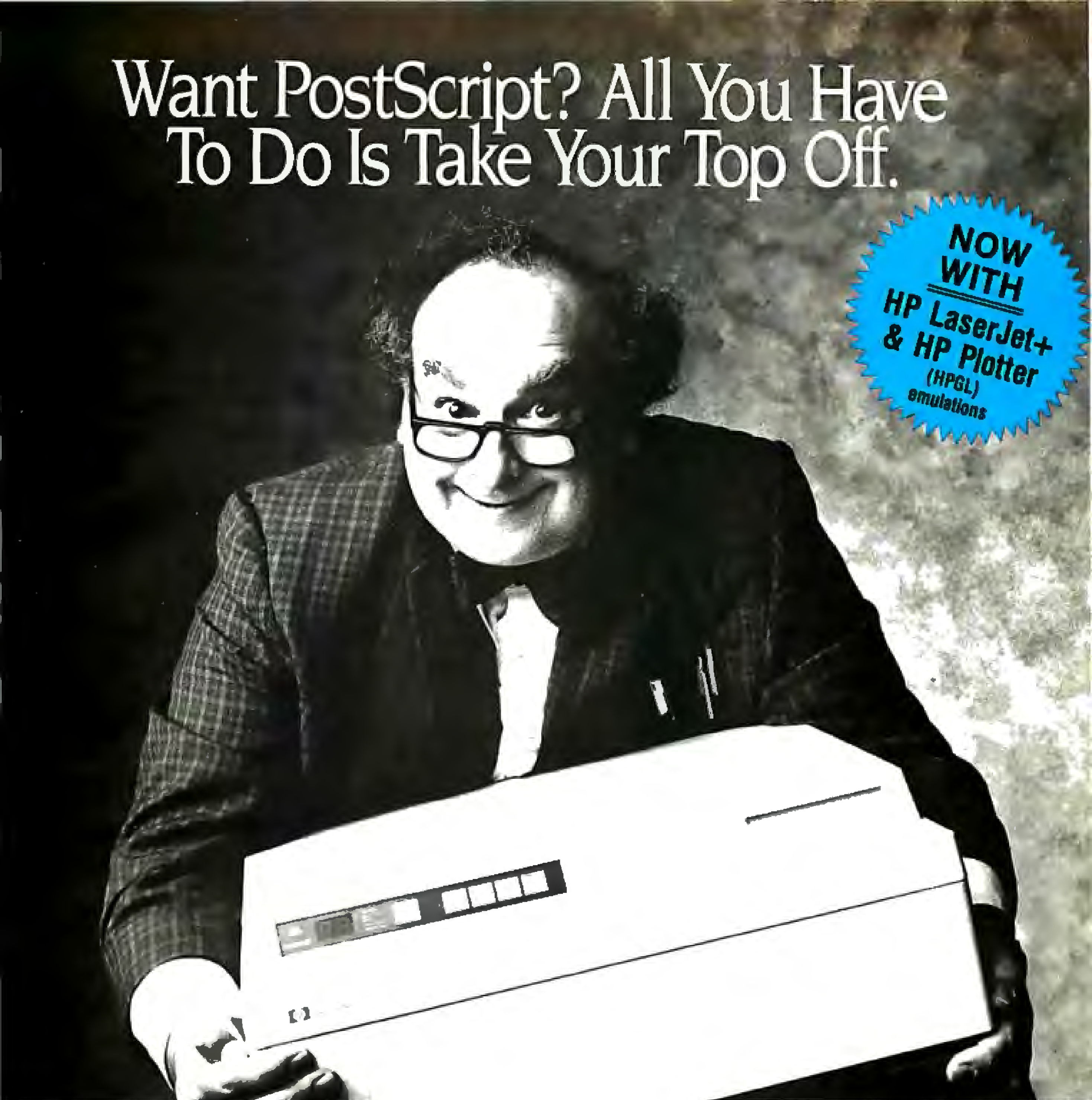

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Inquiry 429

Search and Destroy

Dick Pountain

Remove uninteresting words from your index with a Boring Words dictionary

Last month, I described an algorithm for sorting text files into a list of unique words as the first step toward a book-indexing system. The second step is to search a dictionary of "boring" words, like "and," "the," and "but," for words to be excluded from the index.

To actually produce a dictionary of boring words, you can "hunt and gather" using the Usort program from last month's column. Run it on a few hefty files and manually weed out all the *interesting* words and empty lines. The resulting sorted list will serve as a good start to BORING.DIC; you can add new words at any time.

You need to search this dictionary efficiently. As you read each new word from the text file, you must look it up in the dictionary and then reject it as boring if you find it there. Therefore, this lookup is a potential bottleneck for throughput speed.

Plan Your Attack

Searching algorithms are as various as sorting algorithms—and as important—since searching is the most fundamental of all computer operations. Some obvious instances are `Search and Replace` algorithms in word processors and `Select a Record` algorithms in databases. However, a less obvious example is that every time you execute a program from the operating system, it must perform a directory search.

You can broadly distinguish searches into internal and external types. In an *internal* search, all the data to be searched resides in memory; in an *external* search, it resides mainly on disk. You can choose either one of these for the Boring Words dictionary.

The dictionary itself should be kept in a disk file, rather than embedded in the program, so that you can easily update or correct it. You can either read it into memory when the program starts or access it from disk as you need it; however, the latter method is too slow for it to ever be practical. Thus, an internal search of the dictionary read into memory at the beginning of the program is the most appropriate choice.

Now, we need to choose a data structure for the dictionary. At its simplest, the dictionary is an ASCII text file full of words:

```
a
ability
able
ably
about
above
absolutely
........
```

I say "at its simplest" because it's possible to encode the dictionary in various ways to enhance performance. We could apply text-compression techniques to reduce its size and employ clever algorithms to generate all possible suffixes of a root word (e.g., from "accept," you'd get "accepts," "accepted," and "accepting"). However, it is convenient to start with a plain text file, as we can create, modify, and maintain it with an ordinary text editor; we can add the fancy stuff later.

Since Usort is written in Turbo Pascal, let's treat the words as strings, so we can use the language's string-handling and comparison abilities, rather than reading in a stream of characters. Thus, we need an array of strings (listing 1); this will waste quite a bit of memory since you can't vary the size of an array at run time in Pascal (and most other compiled languages), and strings are actually n by 1 arrays. The "array" `wordtype`, therefore, should be long enough to hold the biggest word likely to occur—16 characters is about right.

However, since the average size of English words is only about six characters, short words like "and" and "but" waste 13 bytes apiece. One 64K-byte segment—on an IBM PC, that's all Turbo Pascal allows you for a single array—holds about 3750 words; as much as half this space is wasted.

We could save memory by reading the dictionary from disk, one character at a time into a one-dimensional array, and maintaining a separate array of pointers to the beginnings of the individual words (see figure 1). However, since 3750 words is enough for the Boring Words dictionary, this seems like overkill. On a 68000-based machine with lots of memory, this problem isn't so critical.

Choose Your Weapons

Having (with a tinge of regret) chosen an array of strings as the main data structure, now we need to search it. I tried three different algorithms to see how they compared in performance: sequential search, partitioned sequential search, and binary search.

The simplest possible search algorithm is the sequential search: Start at one end and run down the array comparing each element with the target string (see listing 2). This is also the slowest search (apart from examining elements at random): You must examine all the elements if you don't find the target and, on average, half of them if you do. However, if the array elements are not in any known order, it is the only method available. If the elements are ordered, you can use either the partitioned sequential search or the binary search.

continued

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

It's natural to expect to find a dictionary in alphabetical order. In this case, you can improve the sequential search itself, since you can end the search as soon as the current element becomes alphabetically greater than the target; for example, if the target is "accept," we can quit if we don't find it before "add." Hence, on average you need to search far fewer elements than you did with the unordered list (see listing 3). Unfortunately, this algorithm doesn't terminate when the target is alphabetically greater than the last element in the dictionary; it just hangs.

You can prevent this either by introducing a test on dictionary size or by adding a *sentinel* (or stopper value), which is greater than any possible target, as the last element in the dictionary. I used "zzzzzzzzzzzzzzz"—rather appropriate for a list of boring words. We could have used the target value itself as a sentinel in listing 2, since it makes the equality test succeed, and omitted the size test.

You can further improve a sequential search by partitioning the dictionary into smaller sub-units and searching only one of them. For a dictionary, the obvious partition is the initial letter. By keeping an index array of pointers to the first dictionary word beginning with *a*, with *b*, and so forth, you can enter the dictionary at the right place and search only those words beginning with the right letter (figure 2 and listing 4). The sentinel "zzzzzzzzzzzzzzz" is the final dictionary entry for z. This is almost the same algorithm used in the sort routine given last month, but using arrays instead of linked lists.

To extract the last bit of power from the algorithm, I decided to sort the dictionary words inside each partition by increasing length (e.g., "a," "an," "as," "at," "and" . . .) rather than alphabetically, on the assumption that small boring words are more common than long ones.

Frequency is a form of ordering; if we know anything about the relative frequencies of occurrence, we can greatly assist a sequential search by putting the most frequently used items first (see listing 5). For this version, we need a sentinel at the end of each partition; I arbitrarily chose a blank or null string (which translates to an empty line in the actual disk file).

The stopwatch told a cheering tale. Running last month's column (17K bytes) as a test file against a dictionary of 1000 words, the plain sequential search took 24 minutes to check every word, while the improved version took 42 seconds; this is more than a thirtyfold improvement!

So there we have it; the triumph of ingenuity over a poor algorithm. Hmm, well, perhaps not . . . . I had improved the sequential search at the cost of a far more complex and inconvenient dictionary structure that was more difficult to update and maintain (each partition must be separately sorted by string length). This version also requires more complex code to read data into the array, as the pointers for the index need to be computed. Changing to a binary-search algorithm gave almost the same improvement in performance using the original alphabetically sorted file.

Divide and Conquer

The binary search, sometimes called the *binary chop*, belongs to the class of algorithms that employ the "divide and conquer" philosophy. To solve a complex problem, reduce it to several simpler subproblems; if these are not soluble, divide them again, and keep doing this until you get down to problems simple enough to solve.

To perform a binary search on a sorted dictionary, first find out which half of the dictionary the target lies in; then find out which half of *that* half the target lies in, and so forth. Eventually, the divisions become so small that you arrive at a single value that either is or is not the target, and the search is complete. Using this method, to find a target among N values, you will need about $\log_2 N$ iterations; for example, for 1000 words, it will take approximately 10 tries, as opposed to 500 for a sequential search.

It's important to note that you can perform a binary search only on sorted data; if the data is not ordered, you can't determine which half of it any particular value lies in. The algorithm (listing 6) works by keeping two *goalpost* variables called

continued

Listing 1: *A string array for the Boring Words dictionary.*

```
type wordtype = string[16];
var boringWords: array [1..3750] of wordtype;
```

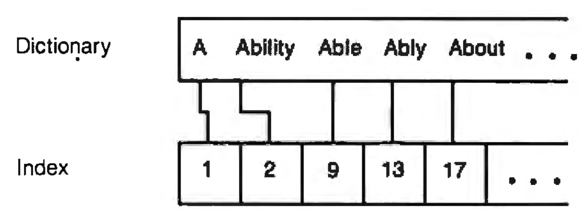

Figure 1: *A memory-saving dictionary using pointers to locate individual entries.*

Listing 2: *An ordinary sequential-search algorithm in pseudocode.*

```
Program SequentialSearch
  Here <- 0
  REPEAT Here <- Here + 1
    UNTIL Dictionary[Here] = Target
    OR Here > DictionarySize
  IF Here > DictionarySize
    THEN Target not found
    ELSE Target found at Here
    ENDIF
```

Listing 3: *A sorted sequential-search algorithm in pseudocode.*

```
Program SortedSequentialSearch
  Here <- 0
  REPEAT Here <- Here + 1
    UNTIL Dictionary[Here] >= Target
  IF Dictionary[Here] > Target
    THEN Target not found
    ELSE Target found at Here
    ENDIF
```

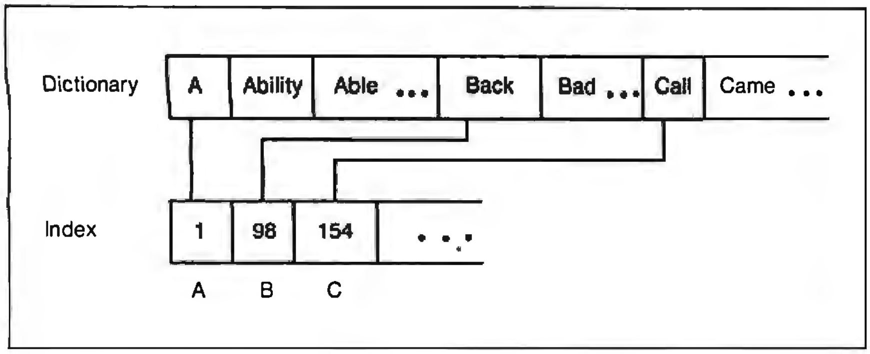

Figure 2: *A dictionary partitioned alphabetically with pointers to locate each partition.*

Listing 4: *A partitioned sequential-search algorithm in pseudocode. The words are alphabetically partitioned and alphabetically sorted within partitions.*

```
Program PartitionedSequentialSearch1
  Key <- FIRSTLETTEROF(Target)
  Here <- Index[Key] - 1
  REPEAT Here <- Here + 1
    UNTIL Dictionary[Here] >= Target
  IF Dictionary[Here] > Target
    THEN Target not found
    ELSE Target found at Here
    ENDIF
```

Listing 5: *A partitioned sequential-search algorithm in pseudocode. The words are alphabetically partitioned and sorted by word length within partitions.*

```
Program PartitionedSequentialSearch2
  Key <- FIRSTLETTEROF(Target)
  Here <- Index[Key] - 1
  Found <- FALSE
  REPEAT
    Here <- Here + 1
    Current <- Dictionary[Here]
    IF Current = Target
      THEN Found <- TRUE
      ENDIF
    UNTIL Found = TRUE
    OR LENGTH(Current) > LENGTH(Target)
    OR Current = BLANK
  IF Found etc.
```

Listing 6: *A binary-search algorithm in pseudocode.*

```
Program BinarySearch
  Left <- 1
  Right <- DictionaryEnd
  REPEAT
    Try <- INTEGER((Left + Right) / 2)
    IF Dictionary[Try] > Target
      THEN Right <- Try - 1
      ELSE Left <- Try + 1
      ENDIF
    UNTIL Dictionary[Try] = Target
    OR Left > Right
  IF Dictionary[Try] = Target
    THEN Target found at Try
    ELSE Target not found
    ENDIF
```

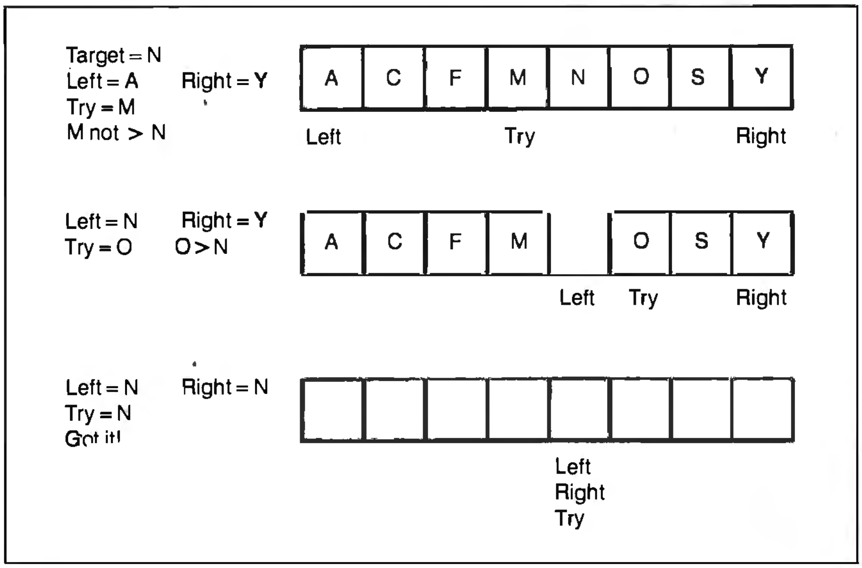

Figure 3: *A diagram of the goalpost algorithm for a binary search (see listing 6).*

Listing 7: *A Turbo Pascal 3.0 implementation of a Boolean function called* Boring( ). *This function returns* True *if its argument is in the Boring Words dictionary and* False *if it is not.*

```
const maxDict = 3750; {maximum allowable dictionary entries}
type wordtype = string[16];
var boringWords: array [1..maxDict] of wordtype;
    dictionary :text;
       endDict :integer;
procedure ReadDictionary;
var i:integer;
begin
  Assign(dictionary,'BORING.DIC');
  Reset(dictionary);
  i := 1;
  repeat
    readln(dictionary,boringWords[i]);
    i := i + 1
    until eof(dictionary) or (i > maxDict);
  endDict := i;              {number of actual dictionary entries}
  Close(dictionary)
end;
function Boring(word: wordtype): boolean;
var left,right,try, svleft, svright: integer;
begin
  left := 1;
  right := endDict;
  repeat
    svleft := left; svright := right;
    try := (left + right) div 2;
    if word < boringWords[try]
      then right := try - 1
      else left := try + 1;
    until (word = boringWords[try]) or (svleft > svright) ;
  if word = boringWords[try]
    then Boring := true
    else Boring := false
end;
```

Listing 8: *Change line 8 in USORT.PAS's main program to this and insert* ReadDictionary; *after line 2 to interface with the* Boring( ) *function.*

```
if not Boring(word)
  then Place(sortList[firstletter],word);
```

Left and *Right*; they begin by pointing at the respective ends of the dictionary. Then we inspect the dictionary entry, *Try* (lying, as near as possible, midway between *Left* and *Right*), to see if it is greater than the target. If it is, we move the *Right* goalpost to one position to the *left* of this *Try*, and try again; otherwise, we move the *Left* goalpost to one position to the *right* of this *Try* (see figure 3).

As you can see, it's possible to hit the actual target by luck before the process narrows the field to a single value. If the target is not found, the algorithm terminates when the goalposts cross over each other (i.e., *Left* > *Right*).

Running the same test we ran with the sequential-search **algorithm,** the binary-search implementation (listing 7) took 60 seconds—slower than my fine-tuned sequential search, but a small price to pay to retain a simple dictionary structure. You can add listing 7 to the Usort program in last month's column to test each word before you sort it to see if it's boring. Change line 8 of the main program to the line in listing 8, and insert ReadDictionary; after line 2. [Editor's note: *A combined listing is available in Turbo Pascal 3.0 source code for the IBM PC and compatibles on disk, in print, and on BIX as INDEX.PAS; see the insert card following page 256 for details. It is also available on BYTEnet; see page 4.*]

You can also tweak a binary search. It's quite easy to partition the boring words by first letter as before and then do a binary search within each partition. A more elegant improvement would be to compute a *Try* point, which is not simply the midpoint between *Left* and *Right* but lies closer to where we think the target belongs. In alphabetically ordered data, a target word beginning with *u* is much closer to *z* than it is to *a*, so we could choose a *Try* point nearer to *z*.

You achieve this *interpolation* search merely by substituting a better interpolation for the expression INTEGER((Left + Right)/2). It's much easier to do for numeric data than for strings, however, as the "distance" between two strings is not easily defined (you need to use more than just the first letter). Thus, it's not appropriate here.

Simplicity Triumphs

If there is a moral to this tale, it's that the simple binary search is the way to go unless you have darned good reason not to. The sequential search is excusable only when you can't easily keep your data sorted or you have little of it (fewer than 20 items). This is true only for pure searching, though; if you need to insert data, that's a different story. Another time. ■

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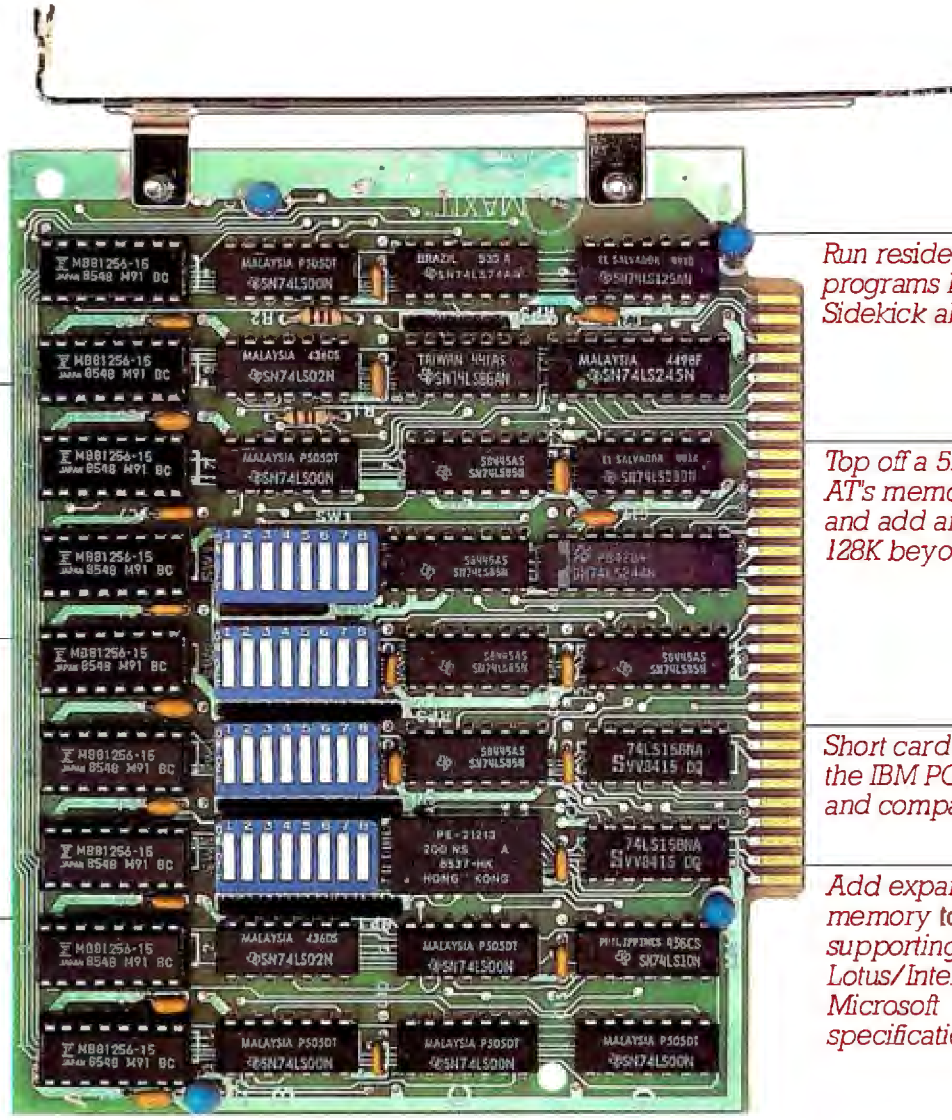

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Moving Toward AI

Ezra Shapiro

A nifty AI trainer and two programs for developing self-contained courseware

For some time, I've been of the opinion that the dividing line between applications and programming languages is an artificial obstacle to tapping the power inherent in today's microcomputer systems. Why should you be forced to limit your activities to what application programmers think you need? Wouldn't it be nice to develop your own specifications for an application?

I'm not alone in this view; witness the success of programmable databases, spreadsheets with powerful macro languages, and the internal command languages of integrated packages like Framework, the Smart series, and Open Access. True, you still have to do some programming, but at least you're freed from having to cope with the headaches of file access, I/O, screen handling, operating system calls, and basic interface design.

This month I'll be talking about programs that are a step in the right direction; all of them push the horizon just a little bit further. They blur the dividing line, and I think that's a good thing.

Artificial Intelligence Delight

Let's say you were going to create some tools for demonstrating AI techniques to a mass audience. What language would you choose? Prolog? LISP? Pascal? BASIC? How about Lotus 1-2-3 macros? After all, Lotus macros can handle variables, subroutines, branching, and Boolean logic as well as numeric functions. And face it, if you wanted to let the public play with your source code, consider that there are more copies of 1-2-3 in day-to-day use than there are of any serious programming language.

That's the thesis behind Robert Benson's If/Then (If/Then Solutions, $69.95 plus $3 for shipping and handling), a marvelous little AI training package built entirely out of Lotus 1-2-3 macros. I admit that had Benson merely called me and explained the product, I would have assumed that he was yet another fruitcake programmer who'd been staring at the screen too long. Fortunately, I was introduced to him at a computer show by Guy Kewney, a British friend with a sharp eye for quality and talent. A few weeks later, Benson walked me through a full demonstration of the package, and I left the session impressed with his intelligence and programming skill. I also took a copy of If/Then, and I've been pleased with it.

If/Then is designed as a step-by-step course for anyone who wants to learn the fundamentals of AI programming. It consists of a large collection of small spreadsheets and a terse but well-written manual. Clear, understandable demonstrations illustrate the basic concepts of AI: forward and backward chaining, knowledge representation, tree-structured rule bases, demons, inference engines, and so on.

These worksheets have little relation to the kinds of things you normally do with a spreadsheet; the example of forward chaining shows the steps a robot would take to locate and turn off a light switch. However, each demonstration is easy to follow. Benson has even implemented a moving arrow that indicates which rule is being tested as his macro programs progress from start to finish.

Some of the worksheets (like the robot) are complete, self-running programs; others prompt you for information and let you construct solutions to simple AI problems. If/Then moves gradually from the elementary to the sophisticated; you'll find it an excellent tutorial. Benson estimates that 10 hours with If/Then should be enough to give you a working knowledge of the rudiments of AI. I'd say he's an optimist; allow 15 to 20 hours.

But don't assume that If/Then is only a home-study course in AI; it's also a brilliant dissertation on the art of writing Lotus 1-2-3 macros. Benson makes the spreadsheet program jump through hoops, and he provides thorough documentation on what he's done and why he's done it. An examination of If/Then reveals a programming style well worth imitating.

Further, because If/Then is done with macros, you can borrow chunks of the source code for your own projects. If you want to create a rule-oriented interface for a "smart" worksheet application, If/Then provides a flexible toolkit.

I wouldn't recommend 1-2-3 as the best environment for heavy-duty AI development; spreadsheet recalculation is probably not the fastest engine for complicated algorithms. If you've got a big project, you'd be better off with a compiler optimized for the job, or with a commercial expert-system shell.

However, if you want to add a friendly front end to a 1-2-3 database, or to perform a what/if spreadsheet analysis that branches on multiple conditions, If/Then can get you started without costing an arm and a leg. I also recommend If/Then for simple prototyping. If you're not positive that an AI approach is the correct method for solving a particular problem, you can use If/Then's macros as the basis for modeling your logic before you invest in more powerful tools.

So if you own Lotus 2.xx and have an interest in exploring the potential of AI, or 1-2-3 itself, or both, this product is a must. It's a small jewel of a package.

But of Course

Bill Appleton, the author of Course Builder (TeleRobotics International,

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P.O. Box 146069, San Francisco, CA 94114. Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

Course Builder lets you manipulate Toolbox routines with nary a line of programming. But that's not the really nifty part.

$299), started with the observation that teachers who wanted to develop computerized instructional materials were often forced to learn how to program. Though this might not seem like a big deal for someone in computer science or engineering, for people teaching subjects like eighth-grade English, say, it was often an insurmountable hurdle. As a result, teachers without programming knowledge—or the time to master a language—found themselves modifying their curricula to match the capabilities of commercially available educational software or simply abandoning the idea of using computers in the classroom.

The existence of the Macintosh Toolbox ROM routines made the situation even more frustrating. Here were all the components necessary for creating dynamite courseware—windows, menus, dialog boxes, click buttons, graphics—organized into convenient modules that could cut development time dramatically. But you still had to learn how to program, and you also had to navigate through the arcane syntax of *Inside Macintosh.* The solution was tantalizingly close but still out of reach.

Enter Course Builder, a direct descendant of World Builder (Silicon Beach Software, $79.95), an earlier Appleton program. World Builder is a graphics-and-text adventure-game authoring system for the Mac. As an author, you create a maze of "rooms" through which the player wanders. You can set up pictures and text descriptions for each room and add monsters, weapons, treasures, and sound effects to make the player's journey more interesting.

Each object you add to the game is constructed by accessing specialized dialogues; you essentially have subprograms for mapmaking, graphics editing, monster creation, and so on. The player, of course, is blissfully unaware of all this when playing the game. He or she collects booty, battles enemies, and tries to figure out the underlying logic of the map. Why not apply the same technique to designing courseware?

That's exactly what Course Builder does. Instead of creating a map of rooms, you begin by laying out a diagram of the structure of your course. A palette along the left edge of the screen provides icons that represent the building blocks of course design: text and graphics display, multiple-choice questions, string matching, essay questions, and so forth. You pull icons from the palette into your work area, then link the blocks by pulling arrows between them. This is equivalent to drawing a flowchart on paper. Once you've outlined the basic structure, you click on each of the blocks and add the actual course material.

The arsenal of possibilities is incredibly rich. Course Builder lets you manipulate Toolbox routines with nary a line of programming. You can develop pull-down menus, dialog boxes with working radio buttons, scrolling text displays, student input areas, whatever. Organizational options allow for straight sequential progression from one area to the next, random drill, or branching access as de-

continued

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You've also got two graphics editors, a drawing editor, and a bit-map editor; sprite animation that can extrapolate motion from a starting position to an end position; the ability to add music from MusicWorks and sound effects captured with the MacNifty digitizer; and spoken output through Apple's Macintalk speech generator. Course Builder will even track the student's answers, measure response time, score the results on either points or percentages, and provide a report when it's all over.

Now for the really nifty part. Not only can you generate impressive courseware without going near a programming language, but Course Builder generates stand-alone applications. You don't need to distribute copies of the program itself; every course you develop is an independent program.

The copy I evaluated was a prerelease version, but I was told that it was essentially in finished form, and I had few problems. I found nothing I'd consider a real bug. Screen repainting was a bit erratic moving from section to section, but that's probably not Course Builder's fault; I assume the glitches are in the Mac's ROM routines. And because the Mac isn't really a multitasking machine yet, trying to run music *and* speech *and* sprite animation *and* requiring student input at the same time isn't particularly effective.

The lack of a real help system was irritating at first. The icons you use to build the structure flowchart are not self-explanatory, and a rudimentary help screen or two would be nice. But after an hour with the documentation and the example files on disk, I began creating courseware experiments with surprisingly little effort.

Course Builder is easy to learn, though I would appreciate a demonstration course that teaches how to use the program. The most extensive sample provided with the package merely advertises Course Builder's features; it doesn't explain how to use them. But on the whole, Course Builder is an excellent piece of software.

The only real competition for Course Builder is Guide (OWL International, $134.95), the hypertext system for the Macintosh. Both Bruce Webster and I wrote about the product in April, and both of us were impressed with it. Guide lets you build a document out of text and graphics elements that are linked in what I termed "a series of visual explosions."

Items Discussed

Course Builder $299
TeleRobotics International Inc.
8410 Oak Ridge Highway
Knoxville, TN 37931
(615) 690-5600

Guide $134.95
Guide Envelope $199.95
OWL International Inc.
14218 Northeast 21st St.
Bellevue, WA 98007
(206) 747-3203

If/Then $69.95
If/Then Solutions
1 Mallorca Way, Suite 301
San Francisco, CA 94123
(415) 346-5886

World Builder $79.95
Silicon Beach Software Inc.
9580 Black Mountain Rd., Suite E
San Diego, CA 92126
(619) 695-6956

Briefly, you can define any region in a Guide document as a "button"; clicking the mouse in a button area reveals hidden information in several different ways. One type of button replaces your original material with new data; you can substitute a full phrase for an acronym, for example. A second button jumps the reader to another spot in the document or to a different document entirely. And a third type pops open a new window of information as long as you keep the mouse button depressed. Guide buttons can be nested for complex branching, and you can group a collection of buttons into a list that serves as a multiple-choice menu.

Guide lacks a number of Course Builder's features—no sound, no editing of graphics, no animation, no grading, and no direct access to the Mac Toolbox routines—but it's certainly a viable alternative for the construction of courseware if you don't need razzle-dazzle effects and testing features.

A major difference between the two products is in the way you build the logic. Guide lets you branch on the fly, from within your document; Course Builder requires that you define your structure at a global level before you add the specifics (though you can move back and forth between the flowchart and the course as needed). Guide is thus more suited to a looser development style. Course Builder also has an edge in both testing and drilling, but the two programs are pretty even for routine instruction, particularly at the high school level and above.

Pricing doesn't favor either program. Course Builder lists at $299, with almost unlimited distribution rights for the courses you develop. I say "almost" because there's a clause in the license that requires a 5 percent royalty on any profit greater than $20,000. (Obviously, TeleRobotics wants a cut of any hugely successful commercial venture, but this shouldn't affect anyone who's a teacher rather than a big-time developer.)

Guide by itself costs only $134.95, but the documents it produces can be read only by other owners of Guide. To distribute courseware, you really need the Guide Envelope package ($199.95). The Envelope lets you create 1000 stand-alone Guide documents that contain the code to allow them to be read without Guide itself. Each of those 1000 Envelopes can be duplicated as many times as you want, so there's your distribution scheme. Thus, for $335 (only $36 more than Course Builder), you get Guide as a development tool and Guide Envelope as the vehicle for unleashing your masterpiece on the world.

OWL International also sells a product called Guidance, which is a true development system, for $2500. Guidance provides all the hooks for a programmer to create a context-sensitive help system for a software package. If you want to see an example, PageMaker 2.0 from Aldus sports a Guidance help system.

Institutions can license Guidance to develop training packages or on-line documentation. Used in this fashion (i.e., installed outside a specific application), Guidance loses its context-sensitivity but retains awareness of its environment. (Guidance can't determine what operation you're performing, but it can figure out what program you're using. Instead of being shown information specifically geared to the task at hand, as would be the case with a full-blown help system, Guidance provides a menu of topics.) Thus, a college or university could use Guidance to provide tutorial or procedural information to students or staff.

My gut reaction to all this is that Course Builder is the better program for pure teaching and that Guide is superior for documentation. But whichever one you choose, you'll be able to generate your own training materials that are equal to the best of today's commercial educational software packages. ■

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Smalltalk/V

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continued from page 32
cept the Zenith Z-181, and it's fast—about twice the speed of my desktop PC. Now, I could ask for a super-twisted LCD like Zenith's (which probably will be out any day now), an EGA- or PGA-style display (probably next year), and for the whole shebang to fold up into credit-card size. But for now, this little 10-pound package gives me everything my desk-bound PC offered, plus more speed.

I work in a videotape-editing facility as an assistant editor. For some time I've wanted a machine at work, and I was considering a Compaq. My mother used to shuttle her Compaq between home and office and now has a right arm like Arnold Schwarzenegger's. Her machine now stays at home. My Toshiba rides comfortably on my shoulder to work, to the gym, and to poolside at my favorite resort. At home, I more often curl up on the couch with the Toshiba than sit at the desk waiting for Baby Blue to finish his post. If the weekly beg-for-new-equipment memo is finished, I'll fly Flight Simulator out to Martha's Vineyard or work on a facilities drawing with Generic CADD. (Try running any CAD package on a Tandy 100.)

Toshiba and Zenith have delivered where IBM failed—again; does anyone *use* a Portable PC? Granted, the Convertible is a bit better, but it doesn't offer the best value. I highly respect your judgment and powers of observation. It's good to find someone who thinks about a subject before becoming opinionated.

Jim McDonald
West Hollywood, CA

Thanks for the report on the Toshiba. I've used one at computer shows, but I've never had one to play with.

I'll continue to try to think about things before becoming opinionated.—Jerry

Glasses and Mice

Dear Jerry,

I was amused at first to find a gentleman seriously recommending a telescope for your eyeglasses, but on second thought I wonder why such a device couldn't be made in stereo. Perhaps neither of us has yet reached that extreme, but, like you, I have met some people who have.

On a more practical note, at times I find myself at a different kind of keyboard, and I have the same sort of problem that we have with the CRT: I can't read sheet music when I'm sitting at the usual distance from the music-rack of a piano or organ. I discovered somewhat by accident that the eyeglasses I used to wear years ago (before bifocals) allowed me to read music very easily at that distance and also made reading the CRT a lot easier. (I am nearsighted.) This is not an ideal solution—adding a pair of glasses to the junk you have to put up with to live a reasonably comfortable life—but it is probably the simplest.

Now for the confounded mouse: by the time this letter reaches you, you will probably have read of the IBM Joymouse, a $20 program that will allow a $20 joystick to perform all the functions of a mouse. Isn't that glorious? You banish the little beast (or save upwards of $80 if you never bought one), and probably gain back a serial port, for a total outlay of about $40, and you never have to roll anything around your precious four square inches again. The folks who could have sold us trackballs have now lost their opportunity forever. (I wonder why nobody ever did sell a trackball for the PC, except as part of a $400 keyboard?) I'm about to go buy a joystick before the prices go up!

Douglas McGarrett
Jamaica, NY

I share your sentiments: The WICO keyboard was wonderful, and we still use ours, but it was just too costly. I can't think why, since trackballs can be bought for $20 or so. I'm trying to convince the DataDesk people that they ought to think seriously about trackballs.

The only way I can find the silly mouse under all the paper is to track him by the tail, and now they're making mice with an IR cordless connection!—Jerry

Computer Pusher

Dear Jerry,

Be warned. This letter contains a powerful curse. It also includes an explanation thereof and a thank-you note. Now for the curse:

May Murphy and all his kin and offspring come to dwell at Chaos Manor and abide there even until the nth generation.

Now I owe you an explanation and, possibly, an apology. Some years ago, you coauthored a story that appeared in *Isaac Asimov's Science Fiction Magazine.* It dealt with acquiring a word-processing computer.

When I had read that story, I knew I had to have a microcomputer. They only cost $12,000. I waited. The years passed, and prices fell as micros improved.

This summer, the curve of falling prices intersected the rising curve of my bank balance. My savings account did not survive the collision.

Thank you for recommending Kaypro. I am now the proud owner of a Kaypro Professional Computer Model 10, also known as a KPC-10, KC for short. KC is an XT clone with hard disk, 8-megahertz CPU, and monochrome graphics.

You once described the Kaypros as being rather basic, but that seems to have changed. The only thing basic is the price: less than $3000. That includes software, a 9-pin dot-matrix printer, and miscellaneous supplies and accessories. The bundled software is not junk, either. It includes WordStar Professional, Mite, and PolyWindows Desk, as well as MS-DOS 3.2 and GW-BASIC 3.1. [Editor's note: *Now called the PC-30, this system comes with a 30-megabyte hard disk, at a cost of $1695, monitor and printer optional.*]

Anybody buying a first computer should strongly consider a Kaypro. I had mine running within an hour after getting it home. I had never used a hard disk before, and I was hesitant about setting up directories, but I need not have worried. You get six auto-load disks with the Kaypro. Dump them in the floppy disk drive, and you have a working directory system running under a menu-type shell. You can escape the menu and run the system from DOS, if needed, but it's rarely necessary.

I had only one glitch, caused by a loosely fitting power cable that kept the system from powering up. There have been no problems since. The AT-style keyboard has a better layout than the IBM PC, but the feel is spongy. (I don't type by touch, though, so I don't mind.)

I have one point to make before I sign off. You describe yourself as a computer user. A user is an addict. You have moved beyond being a mere addict. You are a pusher, spreading computer addiction throughout society in order to support your own habit.

From a fellow addict, thanks again.

Bryan Edenfield
Allendale, SC

Gee, I'm glad you like your Kaypro. Norman Spinrad uses one to write his novels. I used to use a Kaypro 286i AT clone a lot, and I now have a Kaypro 386.

I admit to being a pusher. But why do I deserve that curse . . . that curse . . . that curse . . . ?—Jerry

No Mac Clones

Dear Jerry,

Users have generated an enormous quantity of words discussing the pros and cons of the Macintosh. Business people, on the other hand, have spoken eloquently by their silence—no one has produced a Macintosh clone.

Richard H. Goodyear
Chiriqui, Panama

An interesting observation. Thanks. —Jerry ■

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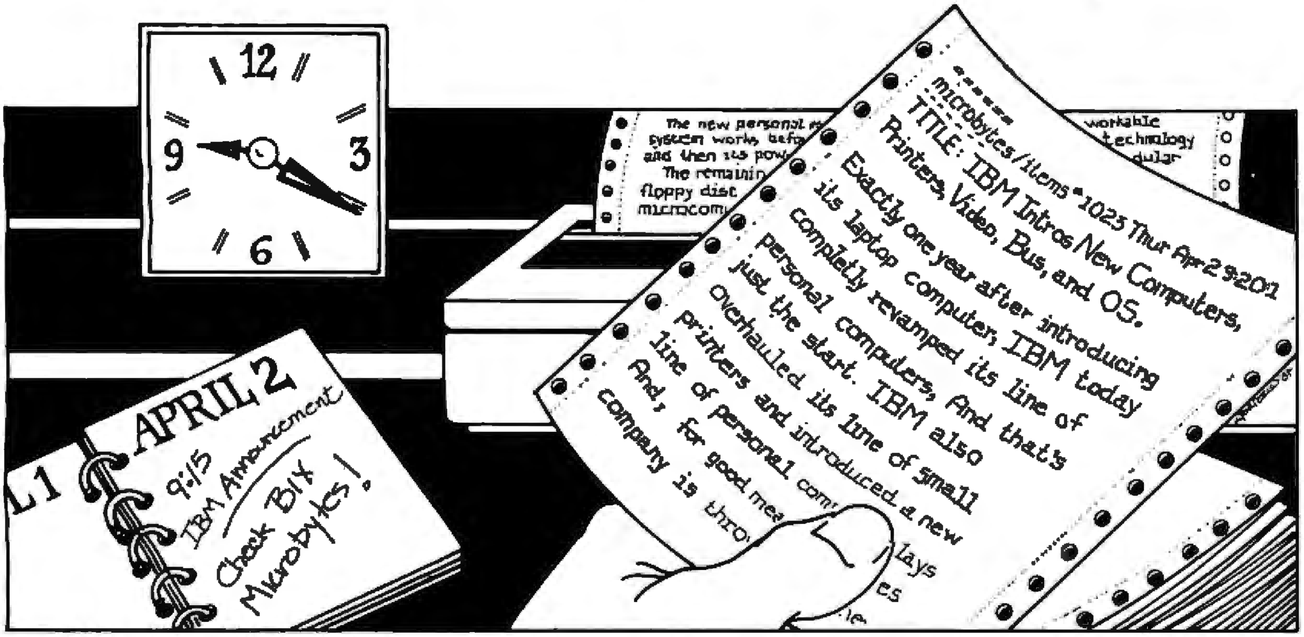

A Detailed Timely Newswire —Via Your Computer

Five minutes after IBM began unveiling their long-awaited Personal System 2 computers and OS/2 operating system at an April 2nd New York press conference, McGraw-Hill's BYTE magazine was feeding that information and more, to thousands of people on BIX, the BYTE Information Exchange. BIX is a worldwide computer conferencing system with over 15,000 users, available 24 hours a day via computer and modem to anyone interested in computers and related technologies.

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AMIGA

This month's Amiga section includes several short threads on a wide variety of subjects ranging from hardware compatibility to software interrupts.

A2000/A1000 COMPATIBILITY

amiga/main #7404, from maploi (Michel Aploi), Thu Apr 30 20:00:44 1987.

I'm considering switching my A1000 with an A2000. I've worked with the 2000 and found that NOT everything runs plain vanilla. Can someone explain the apparent incompatibility between Kickstart 1.2 on disk and in ROM? I want an expandable system but I don't want to throw away too many programs.

amiga/main #7405, from grr (George Robbins, Commodore Business Machines), Thu Apr 30 20:19:52 1987. A comment to message 7404.

The A-number-one problem we've seen is programs that still don't understand about expansion memory and think all memory is chip memory. Every A2000 and A500 with an expansion card potentially has this problem, so I expect these deficient programs to vanish quickly. The production Workbench has a program that "eats" all expansion memory so most of these programs will work, assuming they don't mash the system for games.

Other problems we'd very much like to hear about. We *WANT* these things to be as compatible as possible and have put a lot of effort into it so far.

amiga/main #7417, from maploi, Fri May 1 13:03:50 1987. A comment to message 7405.

OK, I'm aware of the existence of NoFastMem (the one that eats all FAST memory), but some programs still don't work. Music programs like Music Studio, Instant Music, and ProMidi Studio 1.3 will not work.

amiga/main #7421, from jdow (Joanne Dow, moderator), Fri May 1 15:17:29 1987. A comment to message 7417.

Hm, Music Studio is well known NOT to work on 1.2, period. Instant Music should work, though. ProMidi seems to be a little flaky on my 1.2 A1000, so there's a toss-up. Anyway - ANYTHING that doesn't like an A1000 and version 1.2 is 99.99% sure not to like an A2000 or an A500.

amiga/main #7423, from chairmanmao (Mark Olbert), Sat May 2 01:33:32 1987. A comment to message 7421.

Instant Music works fine in 1.2. Do you have expansion memory? I seem to recall you gotta run FixHunk against IM to make it work with expansion memory.

amiga/main #7422, from hazy (David Haynie, Commodore Technology), Fri May 1 16:53:39 1987. A comment to message 7404.

The production ROMs were made by loading the floppy-based Kickstart code, a chunk at a time, into an EPROM programmer. The EPROMs are then put in a tower board that verifies that the right code is in the right order by emulating the final ROM. The EPROMs then go to the ROM vendor, which makes our big ROM from the 4 smaller EPROMs. In other words, the A500 and A2000 ROMs are identical to the code that ends up in the Kickstart RAM of an A1000. If you've ruled out things like programs that don't work with extra memory and other such software bugs, check the ROM of the A2000. If it's a real ROM, keep looking, because that's not where the bug is. However, if it's a tower board containing four 27512 EPROMs, there's a chance that those EPROMs contain an older version of Kickstart. (This can, of course, be verified by asking Workbench for the version of WB/KS that's currently installed.)

SOFTWARE INTERRUPTS FOR INPUT EVENT HANDLING

amiga/softw.devlpmt #4049, from jbergstrom (Jay Bergstrom), Sat Apr 11 11:40:52 1987.

Can someone of greater experience and knowledge lend an ear to this problem?

I can't seem to get the soft interrupts to do much. The objective is to get a soft interrupt (indicating menu pick) from Intuition by way of the user message port. Is there a bit of this code in the listings that can be perused, or some other source of info? I have built and flown the examples in the RKM for handlers and servers. (With the exception of hooking up a device to the serial port to test the receive-buffer-full interrupt. Just being able to set an interrupt vector without problems.)

amiga/softw.devlpmt #4052, from cheath (Charlie Heath), Sat Apr 11 13:38:57 1987. A comment to message 4049.

I hadn't thought about using soft interrupts for menu picks, and don't know how Intuition would take to your setting up the MsgPort signal stuff to do a softint. The only example for softints I've used was the RKM audio.device thing; it seemed to work fine. I think you're on your own trying to set up the Intuition MsgPort for a softint, but it would seem doable - I'd like to know if you succeed!

amiga/softw.devlpmt #4060, from jmackraz (Jim Mackraz), Sun Apr 12 21:40:03 1987. A comment to message 4052.

Yeah, me too. It should succeed, but be sure to keep Intuition from trying to close that port (or for that matter, creating it), since it doesn't expect a change in the characteristics of the ports that IT creates. Open your window with NULL IDCMP flags to

continued

keep a port from being created. Create your port and set UserPort to its address, then modify IDCMP. By the time you ModifyIDCMP( ), you should have done the software interrupt voodoo for your port. Set window->UserPort to NULL before closing your window (or setting flags to NULL), or Intuition will try to delete your port incorrectly.

Forgive me if you know all of this. By the way, are you crashing or not seeing any effect? You can practice by sending a message to yourself in a test program (don't need two tasks) and seeing if you get the basic thing working. If you use Aztec, be sure to call geta4( ) and that new function he has (??) or manually set up your context (a4) and preserve registers.

---

amiga/softw.devlpmt #4083, from jbergstrom, Wed Apr 15 00:43:34 1987. A comment to message 4060.

Thanks for the info. I'll try your approach soon and let you know what color smoke I get. While attempting to test the basic skeleton of the thing, I ran into new problems in the use of the Exec CAUSE routine. The problem in both cases is that the interrupt code never gets executed. No crash, but no interrupt, either. I tried setting the softint bit in the intena register, but I reckon it is already set. Installing my (really innocuous) routine as the handler of all softints has predictably disgusting results. . . the big chill.

---

amiga/softw.devlpmt #4084, from cheath, Wed Apr 15 08:57:34 1987. A comment to message 4083.

Pretty sure you don't want to muck with the intena register for softints. Have you tried the audio.device softint example?

---

amiga/softw.devlpmt #4114, from jbergstrom, Sun Apr 19 03:07:52 1987. A comment to message 4084.

Intuition with softints works very well now. At long last I found the error of my ways: Setting the node type in the interrupt server structure to NT_SOFTINT. With that field set to 0, all works as advertised. Thanks to all for help.

---

amiga/softw.devlpmt #4116, from cheath, Sun Apr 19 03:12:23 1987. A comment to message 4114.

Great! I can't wait for an excuse to try out IntuiSoftInts myself now!

ATARI ST

The ST section this month covers the innovative three-inch solution to the common problem of a loose "glue" chip. An idea to increase the speed of the ST disks by increasing the cluster size is thrown around with some hope that this will also overcome the 16-megabyte volume limit in TOS. Participants reveal shortcuts on the desktop and discuss ways to execute a program more than once without reloading it.

THE THREE-INCH SOLUTION

atari.st/questions #1067, from sgreenwald (Steve Greenwald), Fri Apr 17 00:27:25 1987.

Maybe someone can help with this problem. We have an Atari 520ST with an SF354 disk drive. It has worked fine, but now when we read a disk with data on it, it indicates zero bytes contained in zero files. This happens with any disk we put in. I know it sounds as if the disk drive is fried, but if anyone can help, we would appreciate it.

---

atari.st/questions #1074, from ldyer (Landon Dyer, Atari Corp.), Wed Apr 22 22:48:32 1987. A comment to message 1067.

I have usually found this problem to be related to a gummed-up or misseated glue chip:

1. Pick up your ST and drop it about three inches to the table. This is a tried-and-true technique in our Taiwan manufacturing plant.

2. Get your dealer to reseat the chips for you.

FASTER I/O THROUGH LARGER CLUSTERS

atari.st/main #2103, from davjon (David Jones), Sun Apr 19 18:50:22 1987.

One of the most annoying aspects of TOS file handling is the ridiculous amount of time it spends searching the FAT chain when it is creating files. It struck me that one way to reduce this delay would be to use larger cluster sizes - the bigger the cluster, the less there are, and so the less time TOS takes searching through them. I thought I'd give it a try, so I backed

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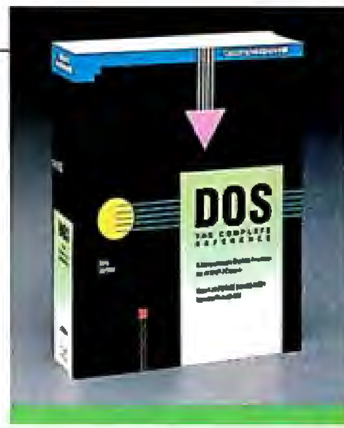

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Inquiry 190

up my hard disk, wrote a few lines of C to change the sectors-per-cluster value in the partition C boot sector and did some tests. I changed the boot record for 8 sectors per cluster (the same as most IBM PC hard disks use) and then tried creating files on the drive. I created 342 files on the disk of varying sizes in 11 minutes. The same operation with normal clusters took 17 minutes. I wonder why Atari plumped for two-sector clusters on hard disk systems? Granted, the bigger clusters are more wasteful, but the hard disk really gains a lot of performance by doing so. The times above included the time to read the files from floppy. But it seems that the actual file-creation process is 2 to 3 times faster when using super-clusters. Comments anyone?

atari.st/main #2104, from mmallett (Mark Mallette), Sun Apr 19 19:07:32 1987. A comment to message 2103.

That's definitely valid. In fact, one of the things that Berkeley did to Unix to make their "fast file system" was to allocate space in several classes of block size. Perhaps a variable-cluster-size scheme would make sense in MS-DOS-style allocation as well - though I think any investment of time in this disk format on the part of Atari would be a waste.

atari.st/main #2105, from mpack (Don Milne, Micropack Ltd.), Sun Apr 19 19:54:17 1987. A comment to message 2103.

I wonder if you can create partitions larger than 16 megabytes with that trick? The FAT size should be the limiting factor.

atari.st/main #2123, from ldyer, Wed Apr 22 22:28:29 1987. A comment to message 2105.

The FAT size is not a limiting factor. Partitions are limited to 16 megabytes because of a sign-extension bug in GEMDOS. Period. Even twiddling the FAT sizes won't help.

MULTIPLE SELECT DESKTOP TRICKS

atari.st/software #397, from mlavelle (Mark Lavelle, Logitech), Sat Mar 7 13:23:48 1987.

In the Desktop, if you hold down the Shift-left key while selecting a file, any other previously selected files stay selected. You can also unselect a file from a group of selected ones the same way.

atari.st/software #399, from sprung (Ron Sprunger), Sun Mar 8 02:59:19 1987. A comment to message 397.

So that's how it's done! I saw a fellow do that, but couldn't see what his fingers were up to. Nifty.

atari.st/software #400, from jimomura (Jim Omura), Sun Mar 8 10:17:56 1987. A comment to message 399.

The Shift-left-mouse key has a slight problem in that it seems to have a cap limit of about 20 files that it can handle on one copy (I can't remember exactly - I just copy one row of icons at a time), but if you keep your folders to a reasonable size, you get the job done fairly quickly.

atari.st/software #401, from alexl. (Alex Leavens), Tue Mar 10 15:55:20 1987. A comment to message 400.

There's no cap limit on Shift-left mouse, but you do have to be careful and click _inside_ the icon exactly, or it trashes the whole group that you've built up and you have to start again. Big pain.

REEXECUTION WITHOUT RELOADING

atari.st/tech #1977, from ianl (Ian Lepore), Thu Apr 30 20:10:00 1987.

Has anyone here ever used the process-termination vector? It is rather sparsely documented. I need to know some basics about it:

What does the stack look like when it gets control? Super or user mode? Have files been closed, memory freed, yet? What's in the registers? Is it safe to mess with d0-d2, a0-a2? Can I make GEMDOS/BIOS/XBIOS calls before terminating or attempting to restart the application? Is this a global thing, or is it on a per-process basis? In other words, if a process installs this hook, should it then Ptermres() and deal with ALL following process terminations, or does the hook go away with the process that installs it, or should the process clean up the hook itself before exiting?

I have a lot more questions, but answers to one or more of these might give me a feeling of bravado; enough so at least to begin experimenting with it.

The thing that leads to all this, BTW, is that I'd like to load a process just once, then execute it multiple times without reloading it. I tried this with Pexec(), doing a "load only," then an "exec only," then trying to do the "exec only" again. Apparently, when the EXECed process terminates, it frees the memory allocated to it by the "load only," so that if the program does any Malloc calls (or even does an Mfree during its startup), you get bombs. Pity. The ideal ARCSHELL, to me, would load ARC.TTP just once, then execute it repeatedly without a reload.

atari.st/tech #1978, from sprung, Fri May 1 02:59:20 1987. A comment to message 1977.

The approach taken by the author of SPEAK.TOS was to JUST LOAD stspeech.tos, then patch in RTSs at the appropriate points and call the program by address, using the info in the basepage returned by JUST LOAD. I plan on using this method to access some code being written in C and assembler.

APPLE

This month's Apple section has two short threads: one on the often-seen-but-seldom-understood ProDOS Error 01, the other a very short solution to a common disk drive problem.

THE INFAMOUS PRODOS ERR 01

apple/language #530, from hmcintyre (Herb McIntyre), Wed Apr 8 20:59:07 1987.

Would someone mind informing me as to what ERR 01 is all about? The manual says to call your dealer. I did - he was no help.

apple/language #532, from mdavis (Morgan Davis, co-moderator), Thu Apr 9 05:33:46 1987. A comment to message 530.

INSERT SYSTEM DISK AND RESTART - ERR 01

. . .is the dreaded "unclaimed interrupt" error. One of your peripheral cards kicked the CPU, and there was no interrupt-service routine installed into ProDOS to handle it. I get this after using my printer in AppleWorks, leaving AppleWorks, and turning the printer off while in ProDOS BASIC, for example. -

apple/language #533, from cullen (Cullen Johnson), Thu Apr 9 13:11:46 1987. A comment to message 532.

Anyone know a good patch to ProDOS so that it just does nothing with unclaimed interrupts?

apple/language #534, from hmckay (Hugh McKay), Thu Apr 9 21:51:11 1987. A comment to message 533.

I seem to remember that Glen Bredon put something up on MAUG on CompuServe to fix this. I also wrote something long ago. I will try to find it and post it for you. In addition to printers causing this, modems will also do it.

apple/language #535, from davewilliams (David Williams), Thu Apr 9 21:57:14 1987. A comment to message 533.

I thought this problem was being fixed in the next release of ProDOS along with changes in ProDOS 16. I didn't have problems with unclaimed interrupts until I started using ProDOS 8.

apple/language #548, from jerryh, (Jerry Hewett, comoderator) Sun Apr 19 10:42:05 1987. A comment to message 533.

I came across this short BASIC program in Open-Apple that will change the interrupt status until Apple gets ProDOS's response to unclaimed interrupts tamed. You should delete line 40 from both if you DON'T use a program selector.

```
10 TEXT: HOME: VTAB 12

20 PRINT "Disabling interrupts."

30 POKE 768,120: POKE 769,96: CALL 768

40 PRINT CHR$(4);"BYE"

10 TEXT: HOME: VTAB 12

20 PRINT "Enabling interrupts."

30 POKE 768,88: POKE 769,96: CALL 768

40 PRINT CHR$(4);"BYE"
```

What the first segment does is an SEI (disable interrupts), while the second performs a CLI (enable interrupts). This program is indeed useful, but only if your hardware or software doesn't require IRQs to function - as nearly all telecomm programs do. This will stop the Super Serial Card from crashing your programs that don't require interrupts, but it won't solve every problem caused when IRQs are enabled on clock/calendar cards and a few other cards that need interrupts to function properly.

As Tom says, we'll just have to wait until ProDOS is upgraded to handle/ignore unclaimed interrupts to completely solve this problem. Pray for rain.

apple/language #537, from hmckay, Fri Apr 10 20:20:32 1987. A comment to message 534.

I wrote the following code to handle an unclaimed interrupt problem. I had two modem programs; one needed interrupts, the other did not. I turned on interrupts on my Super Serial Card. The program using interrupts worked fine. The other one worked fine until I dialed a number. When the call connected, the ERR 01 appeared and ProDOS locked up. The following code is specific to the SSC in slot 2. It reads some of the SSC registers in order to clear the interrupt.

```
300:20 00 BF 40 14 03 60
```

continued

307:AD 15 03 8D 19 03 20

30E:00 BF 41 18 03 60 02

315:00 1A 03 01 00 D8 AD

31C:A9 C0 AD A8 C0 18 60

BSAVE INT.HANDLER,A$300,L$23

Calling this program at $300 installs it. Calling it at $307 removes it. It is specific to a Super Serial Card in slot 2. Change 31C to 99 and 31F to 98 for an SSC in slot 1. If your program is using interrupts, or if it is not the SSC causing the problem, etc., then this routine will only confuse things more.

apple/language #539, from hmcintyre, Sat Apr 11 07:59:31 1987. A comment to message 534.

Could a speech synthesizer be the culprit? Could it be a HARDWARE problem? All I'm doing is booting the system disk. Maybe the CPU is whacked?

apple/language #544, from dwild (David Walker), Sun Apr 12 20:57:37 1987. A comment to message 535.

As I have heard it, ProDOS versions before 1.2 (the first ProDOS 8) just disabled interrupts. That's why they never gave the ERR 01 message. Version 1.2 enables interrupts (so you can invoke the control panel on a IIGS, for instance) but expects the application software to handle them.

apple/language #541, from hmckay, Sat Apr 11 19:10:28 1987. A comment to message 539.

Almost any card plugged into an Apple could generate an interrupt. Some (like the Super Serial Card) have switches that can turn interrupts on and off. I seem to remember a problem involving spurious interrupts from old Apple mouse cards. Usually, however, it is something like a modem or printer card. If you are getting ERR 01 a lot, try unplugging all your plug-in cards except the disk drives and see if it goes away. Then plug in the cards one at a time until it comes back. Then, at least, you will know which card is causing it.

apple/language #542, from westark (Larry Edwards), Sat Apr 11 22:27:24 1987. A comment to message 541.

I have been following this, and suddenly I know why several weeks (or months) ago I had a problem with AppleWorks suddenly going off to wherever!

I noticed a very quick high beep (very quick), then 40 columns and I'm in the monitor! I finally noticed that it happened mostly when someone was on the phone (my modem still plugged in) and they hung up. Wham - AppleWorks zapped! I'm in the "*" monitor, but what's really bad is my 20-megabyte Sider blips - and you know all the files that were in memory? GONE!

The really strange thing was that the last file I had saved to Sider got zapped out of the directory, or at least showed only one block (it was a large file, but there's nothing there now).

I think we're talking about the same interrupt-type problem. My answer was to keep the modem unplugged & back up more.

A QUICK DISK FIX

apple/hardware #792, from craigs (Craig Stevenson), Sat Apr 25 11:25:28 1987.

I need some thoughts on disk drive problems. Some time ago, I had a clone half-height drive in my Apple IIe that gave many I/O errors. I sent it to the shop. "Checks out OK, maybe it's your driver controller card?" (-$25) I bought a new controller card. It would transfer data faster, but still many I/O errors (it doesn't matter if the drive is 1 or 2). I got disgusted, bought a new drive, hooked it up and, voila!, it works fine. Used it all night, no problem. I turned it off and next morning NOTHING will boot! Computer on, bell rings, disk-access light on, disk spins, no boot. It won't boot off a new drive, old (old!) Disk II drive, slot 7, old controller card, NOTHING. The only way to get the critter to boot is using the old controller card and the old - presumably defective - drive. It will boot in slot 7 but still gives its many I/O errors. Very frustrating! Anybody got any ideas?

apple/hardware #793, from jerryh, Sat Apr 25 11:41:25 1987. A comment to message 792.

Try the following and let me know if it makes any difference:

1) Move your drive as far as possible from the computer.

2) If your drive has to be underneath your monitor (setup is monitor on drives on top of the computer), try placing a thick piece of aluminum foil (folded over on top of itself quite a few times) between your monitor and the drive (a tinfoil sandwich!).

3) Use a No. 10 pink eraser (the softer the better!) and clean the contacts along the bottom of the card, then reseat all the chips on the card (clean them as well if you can find some good contact cleaner).

4) Try using a different cable between the drive and the interface card. I spent days trying to find a drive problem once that turned out to be a break in the drive cable! It would work fine most of the time, and that made it a bear to find.

5) If your Apple is stuffed to the gills with cards, try removing all of them except for the drive card. If the system works fine with just the drive card on the bus, then you need to buy a heavy-duty power supply (check your dealer or mail order outfits).

6) While you have the cards out, you might want to try putting them in one at a time (be sure to power down before messing with anything!) just to make sure that one of your cards in combination with the disk controller isn't locking the machine up. This has happened in the past, most notably when a famous 80-column card, a famous Z80 card, and the drive controller card were installed in a certain configuration (the problem has since been fixed - this was years ago).

One of these should do the trick (I hope!). If not, let us know and we'll try to come up with some other ideas/suggestions. . .

apple/hardware #795, from craigs, Sun Apr 26 12:40:15 1987. A comment to message 792.

Many thanks for the quick response, jerryh. Since I'd had all the cards out and checked the seating of all the chips (they're soldered, the jerks), etc., I tried unhooking the new drive. Baby booted. I then changed the cable and you were so right, the system works fine once more (couldn't be the cable, it is brand new. . .had it made up myself. . .watched them do it. . .ALL RIGHT, it's the cable. Argh! :-)) Maybe that was the source of the I/O errors on the old (!) new cable. Maybe I bought a third drive without meaning to. Snuck that past the wife real slick. Hafta remember that one. Anyway, BIX pays for itself once more. Thanks again.

apple/hardware #797, from jerryh, Sun Apr 26 18:14:12 1987. A comment to message 795.

Look at the bright side - you fixed the problem, you now have a list of potential solutions for future drive problems (you *did* dump hard copy; of that, I'm sure. ;-)), and you've got a spare drive in case one of the other two "flies south for the winter."

(I agree - cable problems can drive you crazy.)

MACINTOSH

The recent introduction of the new Macintoshes continues to generate lively discussion among the BIXen. The first thread in this month's Mac window is a quick look at what runs and what doesn't on the Mac II. We follow (and finish) with a long thread, where the whys and wherefores, pros and cons, of the Mac II's non-DMA SCSI port are discussed at length.

THE GREAT MAC II NON-DMA DEBATE

macintosh/soapbox #1300, from nz_mhamel (Michael Hamel), Wed Apr 15 00:12:40 1987.

Could someone possibly explain to me why the slow non-DMA SCSI interface of the new Macs is being touted as such a problem? As I understand it, SCSI runs at 1.5 megabytes per second, peak. The Mac II will read it at >1 Mb/sec. So no huge difference in transfer rate, right? The only other thing DMA will do is allow disk activity to happen without CPU intervention, once it has been set up. This is useful only if the CPU isn't waiting for the disk activity anyway - which means it's only useful if you are multitasking. So, what's the huge difference between a burst of DMA activity that ties up the bus and slows the CPU way down, and an interrupt that takes the CPU away entirely for the same period of time so it can do the disk stuff itself and then come back? I just can't see that it's going to be that important.

macintosh/soapbox #1313, from kswartz (Karl Swartz), Thu Apr 16 14:58:28 1987. A comment to message 1300.

With apologies to frankb, here are some *ballpark* numbers to substantiate the "slow" Mac II multitasking fears.

Assumptions, which I hope are realistic:

(1) 16-MHz 68020

(2) Disk with 1 Mb/sec transfer rate; no buffering in controller

(3) Disk controller accesses memory 32 bits at a time

To transfer a 512-byte block, the disk takes 512 milliseconds once it starts the transfer, or 8192 CPU cycles. Assuming an average of 4 cycles per instruction (just a guess, but it sounds reasonable for an '020), the CPU has time to execute 2048 instructions while the disk is transferring.

During this time, the controller makes a memory reference every 4 ms., or 64 cycles. Figuring 4 cycles per memory reference, that means the '020 has to wait only once every 16 times it tries to reference memory, on the average, assuming no other bus activity.

Looking at these numbers, I think it's clear that the CPU can do quite a bit of work while a DMA disk does its job. When you consider that Unix will often be transferring bigger chunks (usually 8K-byte chunks on a Sun 3, multiply those times by 16), it really makes a big difference. Also, Unix is a known disk hog, which compounds the problem.

You are, of course, quite right in pointing out that it doesn't make any difference without multitasking. But remember, Scully wants to attack the workstation market. The Mac II and

continued

A/UX are leading the battle right now, and a system that wastes nearly 1/100th of a second (8192 ms. for an 8K-byte page) of CPU time reading a single page from disk on a page fault is gonna have an uphill battle against Sun, Apollo, DEC, etc.

macintosh/soapbox #1306, from sjones (Scott Jones), Wed Apr 15 22:22:06 1987. A comment to message 1300.

The difference is that the overhead of a DMA transfer would be less than 7% (that's figuring a transfer rate of 1 Mb/sec from the hard disk, and that the CPU and DMA both take 4 clock cycles to transfer one 32-bit word [at 16 MHz, this is 250 ns]), whereas even the new Mac SCSI utilizes the CPU 100% during the transfer of a sector (and transfers only 1 byte at a time). The difference between 7% and 100% is *rather* large. A/UX users will be stuck in the mud until a third-party vendor comes out with a better drive controller. I did talk with both Charlie Oppenheimer and Didier Diaz [product managers for Mac SE and II, respectively] at the BCS presentation, and both agreed that true DMA would have been nice, especially for A/UX, but they left it out because of cost considerations. Considering that a Mac II will run over $6000 for a reasonable configuration, I don't think that an extra $50-$100 would have mattered, especially when the very, very expensive 68881 chip was included as standard equipment.

macintosh/soapbox #1308, from nz__mhamel, Wed Apr 15 23:05:17 1987. A comment to message 1306.

Goodness me. So you can get a DMA chip that will buffer 4 bytes from SCSI into one 32-bit word and then get on and off the 68020 bus in 4 clock cycles? Which chip is this you are thinking of, precisely?

macintosh/soapbox #1314, from sjones, Thu Apr 16 19:02:22 1987. A comment to message 1308.

Haven't you ever heard of buffering? If IBM can do it, why can't Apple? Simply have the disk controller card buffer the information coming from the disk (buffer a whole track, even) and the disk can operate with 1:1 interleave, regardless of host processor speed. Then, the contents of the buffer can be DMA'd into memory (32 bits at a time). About getting on and off the bus, that is accomplished by having the DMA done in bursts. People have been making cards like this for years.

macintosh/soapbox #1322, from nz__mhamel, Fri Apr 17 19:13:10 1987. A comment to message 1314.

Sure, I've heard of buffering (yes, even in New Zealand!). But you said:

> I don't think that an extra $50-$100 would have mattered, especially when the very, very expensive 68881 chip was included as standard equipment.

So I assumed you were talking about adding *one* chip to the Mac II and doing this, not a whole board. Never mind: I do now see that 1-Mb/sec DMA would have much less of an impact on the 68020 than I expected - the thing is so fast and I'm used to 8-bit micros.

The real issue and the thing that still surprises me is that you're saying that Unix spends a large percentage of its time doing disk transfer. On a 2-Mb machine! What's it doing? Will it still do it on an 8-Mb machine? I thought that all the fuss about disk-transfer rates and interleaves should slowly die away once the 1-Mbit and then the 4-Mbit chips start making themselves known. Is Unix perhaps a secret plot by disk manufacturers to keep themselves in business?

macintosh/soapbox #1324, from rsinger (Gregory Jorgensen), Fri Apr 17 21:37:25 1987. A comment to message 1322.

Unix is well known as a disk hog because of the way its file system is organized. Unix can eat the biggest minis alive - I'm surprised you have any response at all on 68000 Unix boxes with more than a few simultaneous processes. It simply bashes the disk too much.

macintosh/soapbox #1316, from tom__thompson, Thu Apr 16 21:02:42 1987. A comment to message 1314.

A couple of comments:

1) OK, so the Mac II doesn't do DMA. Probably somebody can drop a SCSI board into it that does DMA-SCSI transfers. Yeah, I know, in the Mac II topic I said you'd take a hit on bus cycles moving stuff through NuBus, but we're talking about a 32-Mb/sec bus, versus a 1-Mb peripheral bus. Once on the DMA board, then you let a dedicated processor take control. The Mac has been a closed machine, but now that the Mac II has slots, vendors can take care of Apple's errors.

2) Although IBM's Micro Channel supports DMA, if something with adequate priority wants the bus, the central arbiter will knock it off the bus in 7.8 ms. Once the bus clears, the DMA can restart itself. This points up the very thing that's being hollered about: multitasking. Nothing can hog the bus or resource indefinitely in a multitasking environment, not even a DMA.

macintosh/soapbox #1317, from sjones, Thu Apr 16 21:49:10 1987. A comment to message 1316.

Yay, someone who understands! Although you made one mistake, the NuBus isn't a 32-Mb/sec bus. It takes 3 or more 100-ns NuBus cycles to transfer a 32-bit word. (The NuBus runs at 10 MHz, not at the 15.7 MHz of the 68020.) This works out to 13 1/3 Mb/sec, at most. At least someone else recognizes this as one of "Apple's errors." All along I've said that this *could* be solved by a third-party vendor. I hope that somebody like AST does this soon. Unfortunately, the SCSI interface is not the only place where the Mac II will have problems. The floppy disks, for instance, are real CPU hogs. The Mac II still has an IWM, and Wozniak believed in doing as little as possible in hardware. Because of this, sound files can't be played from a floppy disk. (Read the April BYTE article on the Mac II for more info.) When A/UX comes out, and the Mac II does poorly against Suns, Apollos, and the like, maybe Apple will decide to put more hardware in future machines. Mac III maybe? It's sad that an otherwise advanced machine is held back by a 1976 design.

P.S. It does seem that the times *may* be changing at Apple. The new sound chip is a good example of what they can do, if they put their minds to it.

macintosh/soapbox #1319, from tom__thompson, Fri Apr 17 07:34:19. 1987 A comment to message 1317.

Funny on that. The IEEE proposal doc. (1196) says NuBus is "a 37.5 megabyte per second, 32-bit, computer backplane bus." Probably comes from the block reads and writes where you don't need additional cycles for addressing, but since the Mac II doesn't support this mode, who cares? Even at that, the rate you talk about is more than adequate for SCSI DMA. The IWM for floppy controller is a practical choice. Yeah, it's a CPU hog, but they didn't have to invent a new (possibly buggy) controller, and it's compatible with all of the other Mac disks and software. To me, every machine announced this year (Amiga 2000, Mac II, IBM PS/2s) had to face one major concern: Is it compatible with the existing iron and software? The IWM was the easiest way to resolve one of the major compatibility problems. Second, I hope you don't plan on running a Mac II off of floppies. Whether it's got an '020 or a '386 in it, if you're going to maximize use of the CPU, you're gonna have to use high-speed mass storage (can you say "hard disk"?). The only reason I would use the floppy port on the Mac II is to boot it when it came out of the box and to load in new software.

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macintosh/soapbox #1323, from rsinger, Fri Apr 17 21:34:59 1987. A comment to message 1319.

I can't believe all the concern over the Mac II performance. Did anyone really expect that, on the first time out with a high-performance box, Apple was going to knock DEC, Sun, and Apollo out of business? The Mac II may be slower than those machines, but look at the price differential! Even with the screaming performance built into the Mac II at a more than reasonable price, everyone is crying that it could have been faster! There are a lot of compromises involved in designing, building, and selling a new machine. Design decisions have to be made early on that may seem silly by the time the machine goes to market. Overall, I think Apple did very well at reading the industry tea leaves.

For years everyone has moaned about the closed Macintosh systems, the performance problems, etc., even though the Mac Plus can outperform almost anything in its price range AND offer software an order of magnitude better than anyone else. A few years ago, when the first Macs came out, a box with the Mac II features, especially the color graphics capability and the memory and horsepower to drive it at some reasonable speed would have cost over $30K. Now, Apple gives it to us for under $10K and everyone cries that it should have been a Cray. Come on, folks, give Apple some credit. At least they are on the edge of technology and trying new things, instead of trying to make the fastest clone. And calling the Mac II "1976 technology" is insulting. How old is the 8086 and MS-DOS? And does anyone really think that Microsoft or IBM will be able to deliver a reasonable, working, high-performance, state-of-the-art operating system with multitasking? Their track record sure doesn't show me that they are any better than Apple.

Personally, I'm glad that I can even think of affording something like a Mac II. A few years ago, the same technology cost more than a house and took up almost as much room.

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macintosh/soapbox #1325, from bbayer (Barry Bayer), Sat Apr 18 08:30:06 1987. A comment to message 1323.

> but look at the price differential!

Yes. . .but didn't I read somewhere that Sun just dropped its basic price about 30 percent?

That price differential is getting tighter. (Of course, then Apple can drop ITS price a tad and get that differential back to the original figure. <grin>)

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macintosh/soapbox #1345, from kswartz, Tue Apr 21 11:11:18 1987. A comment to message 1323.

Many people, apparently including John Scully, seem to think (or did think) that the Mac II would nail Sun's low-end market. The company I work for uses Suns and has looked at the Mac II, but at this point we feel that the Mac II is only *almost* there. (These are my interpretations of the company's stand and are not official company policy.) And I'm not asking for a Cray, nor anything even close, merely a Sun 3/52.

You are quite right, though, the Mac II is a very impressive machine. The IBM-Microsoft team has a lot of work, especially since they are stuck with the '86 architecture.

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macintosh/soapbox #1330, from alf (Eric Klein), Sun Apr 19 18:18:36 1987. A comment to message 1325.

Here's my responses to the DMA controversy: I would prefer that Apple did everything possible to take the burden off the main microprocessor, and I think that DMA should have been standard in the Mac II. A graphics coprocessor would also have been nice. But I believe that Apple has begun to back off their policy that the main chip should do everything, witness the Mac II's new sound chip, and also the addition of a math coprocessor. (Even the Mac SE has circuitry that gives 50% more memory cycles to the microprocessor by reducing the amount of cycles that are needed for graphics display.)

Until additional hardware is added to the Mac II, multitasking operating systems will have to use the concept of buffering instead. This is not such a bad solution, because a large disk buffer is an even faster method of disk access than a DMA-based system with a small disk buffer. Note that it is at least theoretically possible that when Apple introduces a multitasking system that they will add a DMA upgrade to the Mac II. I mention this to remind people that they are complaining about an operating system that very little is actually known about.

For the people who think that the Mac II will have problems competing with DEC, Sun, and Apollo: If the Mac II can even think about competing with these machines, imagine how it will do in the PC market!

The actual price of the Mac II is lower than it seems - I have heard that companies that buy large quantities of Mac IIs will get very big discounts off its $3769 price. For example, the price to developers for the machine is only $1884. (The developer discounts for the Macintosh Plus were not nearly as good, to put things in perspective.) The expensive peripherals are being heavily discounted also. Expect the price of a Mac II to fall rapidly over the next two years. I think Apple is starting the machine at a high price because they don't have the capability of making many machines at the present time.

Every time I hear about the OS/2 operating system, it keeps getting bigger. Last I heard, it was about 1 megabyte and slower than the current MS-DOS operating system. I think Apple's operating system will be smaller than OS/2 because a lot of code that an operating system needs is kept in the 256K ROM toolbox. (That toolbox is four times bigger than the DOS 3.3 system that IBM is currently using, to put things into perspective.) Maybe it won't be that memory-hungry.
While you keep complaining about how slow a multitasking system will be on the Mac, you seem to have forgotten that OS/2 is supposed to be slower than the current MS-DOS operating system, even when only one task is being run at a time. I don't think that the Mac multitasking system will look bad compared to the OS/2 system. I just don't get the feeling that the OS/2 system will be well-written, I keep hearing that it's full of bugs and that Microsoft still doesn't know what they would like the final product to look like.

I think the A/UX operating system will not be available this year and that it's not very close to completion. I think Apple wants to get it right the first time and they would rather delay the product introduction than come out early with a mess. Therefore, I'm not willing to guess what A/UX will do and what its limitations will be.

macintosh/soapbox #1336, from mdavis (Morgan Davis), Mon Apr 20 03:05:30 1987. A comment to message 1330.

Seems to me that Scully said quite the contrary during a recent panel discussion at one of the Mac expos about some

continued

earlier Macintosh products. To the effect of, "We'd rather get it out to you so you can play with it now, rather than wait three or four more months for a debugged version."

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macintosh/soapbox #1368, from nz_mhamel, Fri Apr 24 22:19:44 1987. A comment to message 1323.

Yes - well, I think we've sorted out what a DMA chip or card would *do* : useful things in direct proportion to the amount of time the Mac II spends actually doing disk transfers. The trouble is that at 1 Mb/sec, to see any impact, you have to move a *lot* of stuff to the disk, far more than a Mac (do we call it the Mac 1 now?) normally does. I've never used Unix, but sjones is assuring us that 200K/second for long enough to notice is, if anything, an underestimate. That's really quite incredible. I thought Unix was supposed to be a Good Idea, not some kind of a monster. Do I take it that virtual memory is to blame for this? If so, give us real memory.

---

macintosh/soapbox #1370, from cheath, Fri Apr 24 22:29:03 1987. A comment to message 1368.

With multitasking, and a non-DMA disk, the nastiness comes in loosing characters doing serial I/O and in display glitches and mouse pointer jumps. The machine just feels bursty.

---

macintosh/soapbox #1375, from dgoldsmith, Sat Apr 25 20:39:42 1987. A comment to message 1370.

Macintosh SCSI I/O is performed with interrupts enabled, so none of the problems you describe occur. The only real disadvantage is, as everyone has already pointed out, that the CPU is tied up during the actual data transfer (not the disk seek, just the actual moving of bytes). Depending on how many bytes you're moving, this may or may not have a significant impact on performance. Depending on whether the SCSI port or the CPU is the limiting factor in how fast bytes can be transferred (and thus how long the CPU is tied up moving the bytes), it could be a bigger win to put in a faster CPU (which benefits you all the time) than to put in a DMA controller (which costs money and does nothing when no I/O is going on). I don't know enough about hardware to discuss the cost or benefits, but this is the fundamental trade-off in dedicated vs. shared hardware.

---

macintosh/soapbox #1376, from nz_mhamel, Sat Apr 25 21:47:27 1987. A comment to message 1375.

Yeah. The 68020 in the Mac II should be able to grab bytes from SCSI and stuff them away at an appalling rate if you write an unrolled loop made of

```
move.b (a0),(a1)+
```

Once that gets into the cache, it will execute in very few clock cycles. I can't work it out because I don't know how many it takes to get to the SCSI chip, but it's got to be under 15 on average and thus moves over 1 Mb/sec at 15.67 MHz.

This means it's *not* like non-DMA interfaces on other machines, like the Amiga or (dare I say it?) the Mac Plus. They really are limited by CPU speed. Even the Mac SE with its hardware support can hit only 550K/sec. Perhaps sjones can tell us what speed the Amiga's non-DMA SCSI interface that he keeps referring to manages?

Incidentally, why *does* the Mac II run at 15.67 MHz? NuBus has its own clock, the video cards have their own clock, so why run at exactly twice the Mac speed? It wouldn't be because of AppleTork would it?

continued

macintosh/soapbox #1384, from tom_thompson, Mon Apr 27 09:08:44 1987. A comment to message 1376.

It's probably that and at least the floppy drives. Apple engineers told us that a number of components - particularly the IWM - have divided by two circuits and effectively run at the old Mac clock rate. Why? It was easier to design it that way and - most important - still provide compatibility.

IBM

This month's IBM section covers both the old and new of PC and PS technology. We start off with a simple question on setting up a PRINT.COM file that gets lots of solutions. Then there's a lively discussion of the problems and wisdom of upgrading from MS-DOS 3.1 to 3.2. Turning to the PS line, the compatibility of the new bus is discussed, followed by some thoughts on using dual monitors.

USING PRINT IN A BATCH FILE

ms.dos/commands #549, from aorrell (Andrew Orrell), Thu Apr 9 00:55:08 1987.

I know I _used_ to know how to do this but. . .I have a batch file that has the line

PRINT

in order to install the print.com driver.

When the batch file gets to that line, it stops waiting for you to input the device or a carriage return, for which it will use the LPT1:. Okay, you all know that, BUT how do I get the batch file to supply the PRINT prompt with the CR so I don't have to watch it? This comes in the middle of a long autoexec.bat, in a machine that does _a lot_ of device checking, so when I boot up, I just fire that puppy up and go get coffee. I don't want to come back in the middle JUST to hit the CR. I know it can be done and it is simple, I just can't remember. Thanks.

ms.dos/commands #550, from wgivens (Wayne Givens), Thu Apr 9 01:39:13 1987. A comment to message 549.

- Print in Batch File:

PRINT / d:lpt1

This will (silently) do the job - thank whoever gave it to me (on BIX) about a year ago!

ms.dos/commands #551, from cgodwin (Charles Godwin), Thu Apr 9 19:37:42 1987. A comment to message 550.

This works only with DOS 3.0 and up. Before that you could do this:

ECHO Y >yes

PRINT <yes

DEL yes

ms.dos/commands #552, from bradc (Brad Chase), Mon Apr 13 20:42:12 1987. A comment to message 551.

You could use this:

echo prn | print

Actually, this will work for any device - just replace the "prn" with the device you want to use.

ms.dos/commands #553, from mite (Eric Boehm), Fri Apr 17 21:35:17 1987. A comment to message 549.

The way I do this (MS-DOS 2.11 on Zenith Z-100) is to create a file with a carriage return in it such as "copy con return," type a return, CTRL-Z, put the line PRINT <RETURN >NUL in your autoexec.bat. Make sure you have a files=10 in config.sys (at least) and make sure that "return" is in the root directory or use PRINT <d: \ pathname \ RETURN >NUL. This supplies a carriage return to make the device the default LPT1: and redirects output to the null device so you never see it.

THE MS-DOS 3.1/3.2 UPGRADE PATH

ms.dos/secrets #1553, from dstarr (David Starr), Sun Apr 5 21:32:05 1987.

I am thinking of upgrading from Panasonic DOS 3.1 to IBM DOS 3.2. Is this as easy as I think? In principle I use the SYS command to replace the hidden files like IBMIO and COMMAND.COM. Then I use COPY to replace all the DOS utilities with the new ones that come with 3.2.

Now for the gotchas: I am *not* running true-blue hardware. I have a Panasonic Business Partner with a no-name hard disk system. I am currently running the DOS 3.1 that came with the Panasonic on the principle that software ought to match the machine. The hard disk came with its own INIT program that had to be run before FORMAT or FDISK.

On the good side, I FDISK'ed the whole 20 Mb as the DOS partition. I plan to back up everything just in case DOS 3.2 turns nasty and eats up my disk. I realize that I need to hang onto the Panasonic version of GW-BASIC, since the IBM BASICA still needs ROM BASIC to run. I have booted IBM DOS 3.2 off a floppy, and it appears to run (boots up, does not crash immediately, and DIR works). The Panasonic appears to be a good clone. I have been running BASIC, Symphony, Lattice C, and other stuff with no weirdness.

I don't know if Panasonic made changes in their DOS to make Panasonic hardware look more like IBM's. If the hardware is the same as IBM on all levels, then I am home free. If the hardware is a little bit different, and changes were made in DOS to compensate, then I have a problem. I would appreciate any comments before I blow a good working system away.

ms.dos/secrets #1554, from skluger (Sigi Kluger), Sun Apr 5 21:44:36 1987. A comment to message 1553.

You can always redo and bring up 3.1 again. Just be sure NOT to follow the instructions that come with PC-DOS 3.2 and instead simply do the SYS C:.

Also, be sure to replace ALL utilities after you have verified that it works.

ms.dos/secrets #1561, from jfleming (Jon Fleming), Mon Apr 6 20:39:16 1987. A comment to message 1554.

>SYS C: to go from 3.1 to 3.2

I've tried that on my turbo XT clone, an old original true-blue XT, and a Fountain AT clone. It always failed; "Not enough room for system on destination disk" or some such message. Same thing even if I deleted the hidden files first.

ms.dos/secrets #1563, from skluger, Mon Apr 6 21:24:15 1987. A comment to message 1561.

Assuming that you used FORMAT to put the 3.1 system on and haven't fumbled with COMMAND.COM, delete C: \ COMMAND.COM and retry the SYS C:. Should work then.

continued

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Inquiry 141

ms.dos/secrets #1564, from rjsmith (Raymond J. Smith), Mon Apr 6 23:11:59 1987. A comment to message 1561.

Re: "Not enough room for system on destination disk": The solution is to load the directory entries for the hidden files with hex 0s, after you have deleted both files (after making them normal files, of course). You *must* fill the *entire* directory entry. This fools the SYS program into thinking it's a virgin disk, so it transfers both files without any problem. You can use Norton's NU.COM or IBM's Disk Repair to do the job.

ms.dos/secrets #1565, from irae (Ira Emus), Tue Apr 7 00:06:51 1987. A comment to message 1564.

Re: setting the first entries in the directory to 00H:

Do not dare do a chkdsk / f after that or it will report about a zillion lost clusters and waste your disk. It is possible that there is not enough room on the disk for real; I believe that up until PC-DOS 3.2 both ibmbio.com and ibmdos.com had to be contiguous, and that requirement was removed in 3.2. Also, if you change brands, i.e., IBM to generic MS, those two system files have different names, and the SYS program will not install to a disk with the other names already there. My solution for making room has been to go into the FAT table and replace the first 10 or so entries with 00h, and then running "chkdsk / f" which turns those into "file000x.rcv" or something, which, when deleted, leaves room for the system. There is one danger, though, probably one or more files will be DESTROYED, some snooping with Norton will tell you which ones and you back them up and restore them when you're done. Again a reminder, THIS METHOD IS DANGEROUS, but it works.

ms.dos/secrets #1569, from rjsmith, Tue Apr 7 06:56:40 1987. A comment to message 1565.

Re: "program will not install to a disk with the other names already there":

That's the whole purpose of deleting them and then writing over the filenames with hex zeros. Even when deleted, SYS.COM picks up the hex E5 and the remaining characters and says uh-uh. I must admit that it never occurred to me that someone would do a CHKDSK / f. . . it does indeed trash files whether you respond with an n or a y. I experimented and discovered that going from IBM PC-DOS 3.1 to IBM PC-DOS 3.2 results in the following:

1. IBMBIO.COM (9564 bytes in 3.1, 16,369 bytes in 3.2) fits into the same spot occupied by the earlier version and is contiguous after a SYS d:.

2. IBMDOS.COM (27,760 bytes in 3.1, 28,477 bytes in 3.2) fits okay, but is not stored contiguously and is rather badly fragmented. This would cause a minor problem with disk optimizers (they won't move hidden system files) and will result in a slightly longer IPL time (mucho head movement). This would not be the case if you move and then delete one or two files stored directly behind IBMDOS.COM before doing the other dirty deed.

I really don't think it is wise to ". . . go into the FAT table and replace the first 10 *or so* entries with 00h. . ." since, as you observed, "probably one or more files will be DESTROYED." I guess the question is "Do you really wanna go to 3.2?" If so, and you won't or can't follow the instructions in the manual, this is the only other way short of patching SYS.COM.

ms.dos/secrets #1570, from matt.trask (Matt Trask), Tue Apr 7 08:29:43 1987. A comment to message 1565.

Ever since DOS 2.0, it's been possible to use SYS to move up to new versions. The requirement for IBMDOS to be contiguous was removed for that release. The problem occurs when a disk was prepared with MS system files rather than IBM system files - if the first two names in the root directory are not IBMBIO.COM and IBMDOS.COM, SYS will abort with the "not enough room" message. When I was at Leading Edge getting the Mitsubishi PC ready to ship (revealing my age now), we taught the SYS program on the Mitsubishi DOS how to overwrite the system files if their names were IBMBIO/DOS without changing the names. I think most generic DOS versions do that now, but don't hold me to it.

ms.dos/secrets #1555, from drifkind (David Rifkind), Sun Apr 5 22:49:16 1987. A comment to message 1553.

Considering the really minor differences between 3.1 and 3.2, do you have any reason to want to change?

ms.dos/secrets #1556, from skluger, Sun Apr 5 22:59:43 1987. A comment to message 1555.

I have to agree with someone reviewing 3.2 in a magazine a few months ago: "XCOPY alone is worth the price."

I have NSWP and other sweepers and tons of cumbersome menu-driven file-copy utilities, but I don't know how I ever got along without XCOPY.

ms.dos/secrets #1559, from rduncan (Ray Duncan), Mon Apr 6 01:13:07 1987. A comment to message 1556.

Ah, but the version of XCOPY from the "generic" MS-DOS 3.2 will work very nicely with all of the 3.1 DOSes I am running (PC-DOS and Compaq DOS). So does REPLACE, which, like XCOPY, is extremely useful. So you don't really need to reformat your hard disks for 3.2, just copy over those two utilities and you'll be happy!

ms.dos/secrets #1560, from dstarr, Mon Apr 6 19:51:28 1987. A comment to message 1555.

Thank you all for your input. I will give 3.2 a run in the near future, when I get a free hour or two. I started thinking about 3.2 when I got tired of the "greenscreen" card that comes with the Panasonic. The character font in text mode is irritating to my eye. I like the IBM monochrome card's font much better. I put an IBM monochrome card in the machine thinking I could switch it on with the MODE command. Doesn't work. The MODE command furnished by Panasonic only sets the graphics resolution on the Panasonic card. So I figured I could use an IBM MODE program to turn on the IBM monochrome card. When I dug out the IBM DOS and tried to run the IBM MODE under Panasonic DOS 3.1, I got the "Wrong DOS Version" error message. Since I use the machine for commercial software development, I started thinking that I really ought to be running the latest IBM stuff to be compatible with my customer base. Now I have heard somewhere that all you get from DOS 3.2 is network support (which I don't care about). I also hear that it eats up yet more RAM and disk space.

PS/2 MICRO CHANNEL BUS COMPATIBILITY

ibm.ps/model.50 #2, from mjk (Martin Kochanski), Thu Apr 2 11:05:09 1987.

Is it true that *no* existing PC cards will work in the Model 50 and above? If so, is there any prospect of some sort of card adapter to plug into the Micro Channel and act as a motherboard for the old-style 8-bit cards? From IBM or anyone else?

continued

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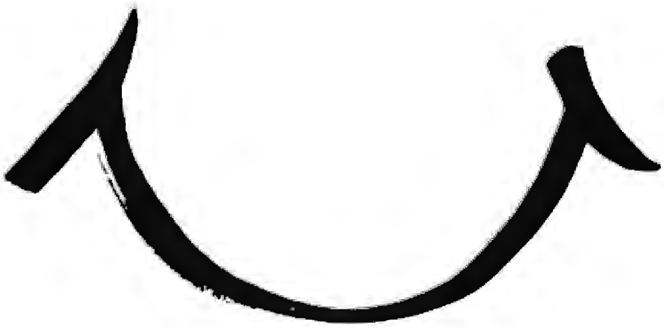

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BYTE887

ibm.ps/model.50 #33, from howardm, Fri Apr 3 23:57:56 1987. A comment to message 2.

Micro Channel machines WILL NOT ACCEPT PC cards. I doubt an adapter could even be made. The Micro Channel looks great. It will allow for much better file servers, and other bus-limited applications will be faster.

ibm.ps/model.50 #4, from p.handsman (Peter Handsman), Thu Apr 2 12:00:01 1987. A comment to message 2.

Even more, are the Micro Channels for the 50 and 80 models compatible, plug-wise?

Or must third parties design and stock two sets of cards?

ibm.ps/model.50 #35, from howardm (Howard Marks), Fri Apr 3 23:59:38 1987. A comment to message 4.

They are compatible. Only one set of add-in cards was announced.

USING TWO DISPLAYS WITH THE PS/2

ibm.ps/graphics #104, from mjwhite (Michael White), Wed May 6 08:45:20 1987.

Under the old regime, you could have two video adapters installed in the PC by using a mono and a CGA (or EGA). This was very handy where you needed to see more information than could be displayed on a single monitor.

I have not been able to determine whether this is possible with the new PS/2s. It would appear not, with the VGA built in. Any one have any ideas?

ibm.ps/graphics #109, from mced (Edward McNierney, Number Nine Computer Corp.), Wed May 6 23:18:33 1987. A comment to message 104.

Sure. The on-board VGA does not need to be used at all. Any add-in board can provide its own direct video output and totally ignore the VGA. Or an adapter plugged into the single video expansion slot can either route the VGA's output out through its own connector or take its own output (or the VGA's data) and route it out through the system DAC and out the connector on the system unit.

ibm.ps/graphics #111, from mjwhite, Thu May 7 09:40:12 1987. A comment to message 109.

So the special "video" slot (with the extra connector) allows you to bring the VGA output onto an adapter AND/OR pump input back into the VGA.

Is this what the special hi-res adapter that drives the top-of-the-range screen (the 8514, I think) does? Is it possible to bring VGA data onto an adapter, message it, then pump it back through the DAC and out the hole in the back?

Also, I would have thought that if you were using a completely independent video adapter that provided its own video output, you would have to disable the VGA in some way to avoid memory conflicts or the like.

ibm.ps/graphics #114, from mced, Thu May 7 21:20:20 1987. A comment to message 111.

You can have your cake AND/OR eat it, too. The 8514/A video adapter takes some video information (I'm not sure what) from the VGA and then pumps it back out. The standard board is 4 bits per pixel, but with memory add-on you can get 8 bits by essentially layering 4 more bits on top of the data being sent out to the DAC.

ibm.ps/graphics #123, from waveframe (Glenn Edens, Waveframe Corp.), Tue May 12 23:06:05 1987. A comment to message 104.

On the PS/2 Model 30 Tech Ref manual there is a reference to a power-on time search for another display adapter, which will then become the primary. It is not clear if this means CGA, EGA, etc., or if it means the VGA enhancement card.

32-Bit Forum

The 68000 processor line and its associated memory-management units created a great deal of discussion on BIX recently.

COMPARING MEMORY-MANAGEMENT UNITS

cpus/680x0 #134, from intel (Cliff Purkiser, Intel), Wed Apr 29 02:13:37 1987.

I'd like to ask a question as a totally unbiased observer. :-) It seems to me that 68030's MMU is a subset of the 68451 PMMU. If this is true, then 68030 won't be compatible with the 68020 and 68451. Is this true?

The other question is, how many people actually use Mot's MMU as opposed to designing your off-chip MMU out of gate arrays? I know that Sun did this with their famous Sun MMU. Chuck, do you think you'll be able to plug a 68030 into a Sun 3/xxx and run Sun Unix unchanged?

cpus/680x0 #135, from killer1 (Carrell Killebrew), Wed Apr 29 02:26:20 1987. A comment to message 134.

Mot acknowledges publicly that the 68030 MMU is a subset of the external MMU. Most of the customers I have talked to who use Mot CPUs do not use Mot MMUs. They build their own custom MMU (as you put it, "out of gate arrays").

cpus/680x0 #136, from reviews6 (Joel West, Western Software Technology), Wed Apr 29 08:54:59 1987. A comment to message 134.

>The 68030 is certainly a subset of the 68851 and 68020 combination.

However, no one has used the 68851 to date, since they haven't been available in significant quantities. In about two years, probably most of the designs will be using on-chip memory management if they don't use their own custom solution (a la Sun).

The biggest user of the 68851 will be Apple. It's not clear if most Macintosh IIs will eventually have the 68851, but they have made it clear that it's a prereq for any machine to run Unix.

cpus/680x0 #137, from skluger (Sigi Kluger), Wed Apr 29 11:12:08 1987. A comment to message 134.

The 68030 contains a subset of the 68851 (not 451!) PMMU - the one that still doesn't work right :-)

cpus/680x0 #138, from cmcmanis (Charles McManis), Wed Apr 29 20:12:31 1987. A comment to message 134.

Certainly it wouldn't work right out of the box, so to speak. However, a lot of the MMU stuff is crammed into the machine-dependent code so it should not be too tough to port. (Of course, we would take a hit on performance. :-)) Another user of the nonexistent (well, barely existent) '851 is Apollo. They have an emulator plugged into their DN3000 product. So both they and Apple will provide some demand for sure. ■

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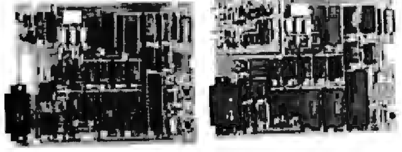

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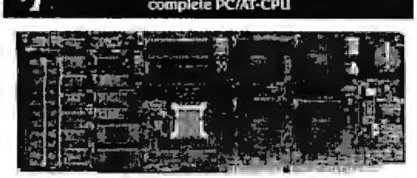

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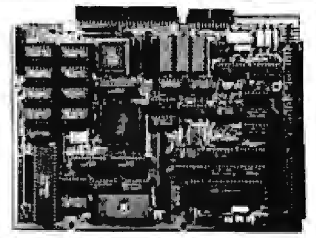

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- Waitstate generator
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- [illegible] tion interface
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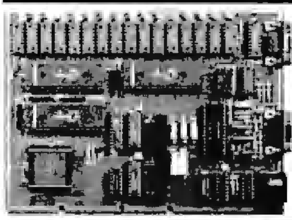

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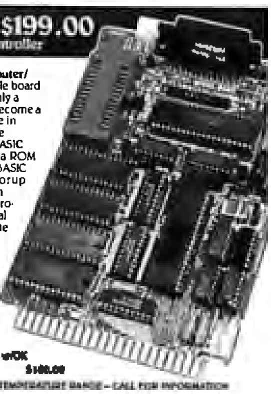

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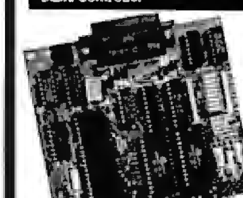

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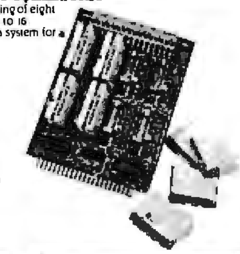

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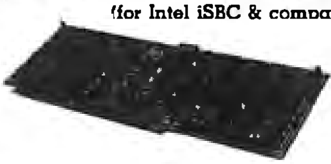

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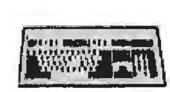

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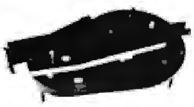

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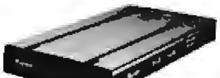

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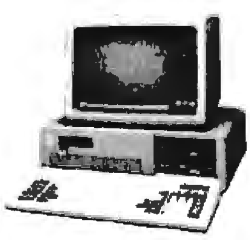

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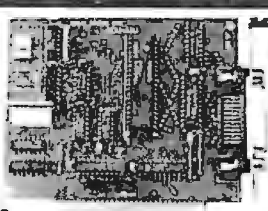

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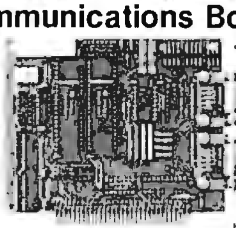

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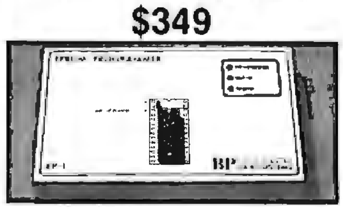

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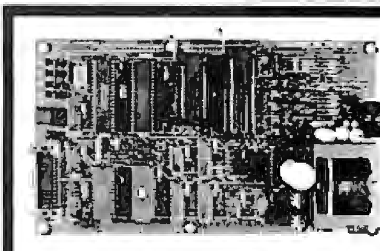

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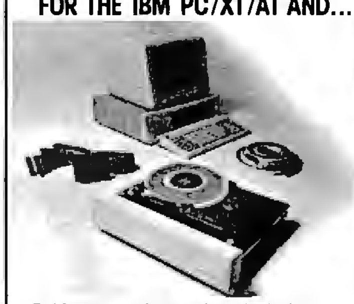

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The Amazing A-BUS

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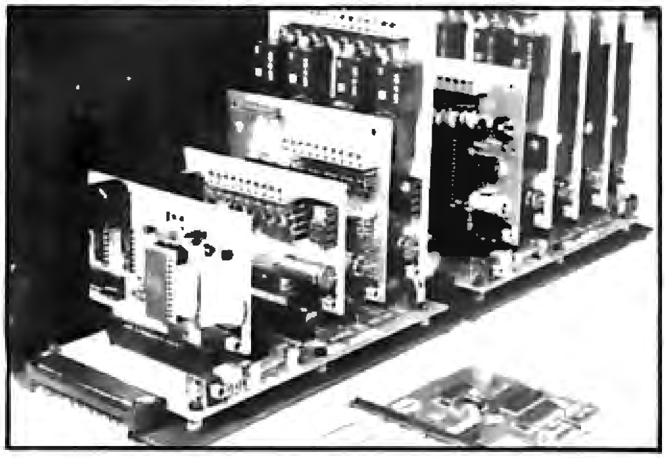

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

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The A-BUS is backed by Alpha's continuing support (our 11th year, 50000 customers in over 60 countries).

The complete set of A-BUS User's Manuals is available for $10.

About the A-BUS:

- All the A-BUS cards are very easy to use with any language that can read or write to a Port or Memory. In BASIC, use INP and OUT (or PEEK and POKE with Apples and Tandy Color Computers)
- They are all compatible with each other. You can mix and match up to 25 cards to fit your application. Card addresses are easily set with jumpers.
- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples).

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Reed Relay Card — RE-156: $99
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Digital Input Card — IN-141: $59
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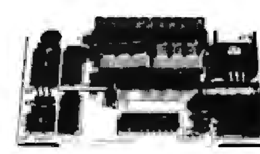
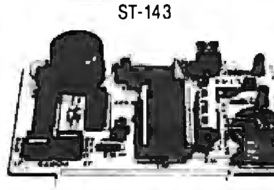


ST-143



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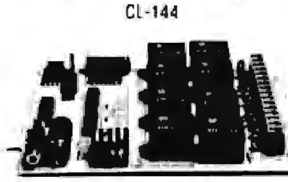

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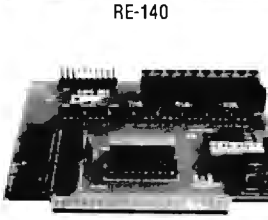

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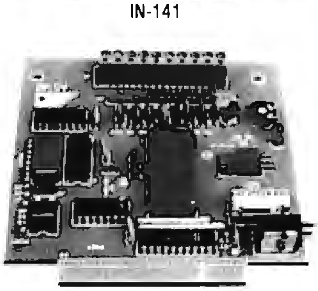

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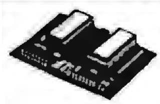

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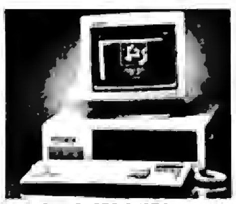

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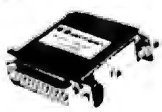

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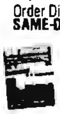

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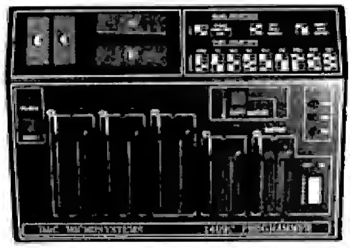

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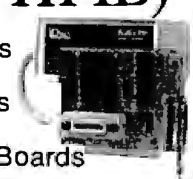

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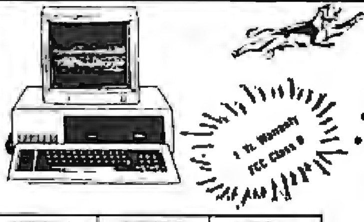

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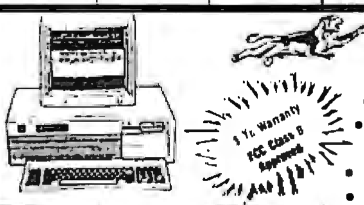

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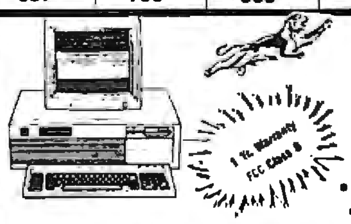

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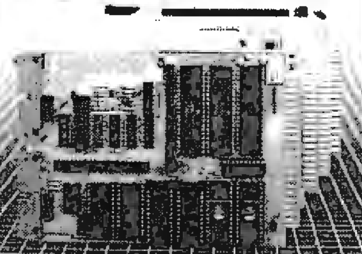

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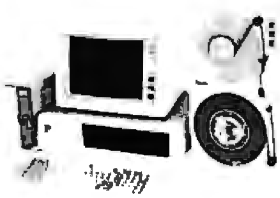

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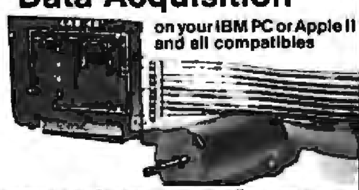

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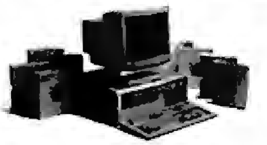

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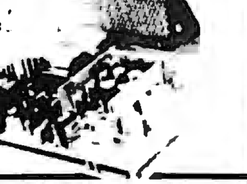

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74HC10	.29	74HC245	.89
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74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC595	1.19
74HC85	.79	74HC688	.79
74HC86	.39	74HC943	8.95
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74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
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74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
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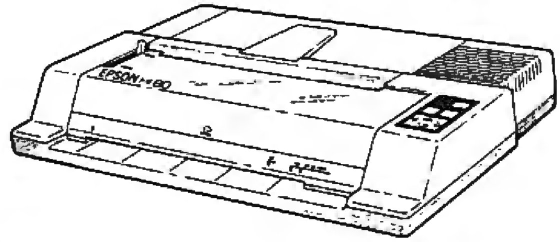

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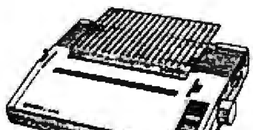

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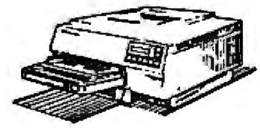

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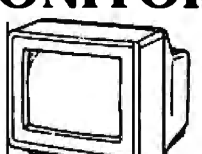

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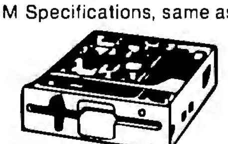

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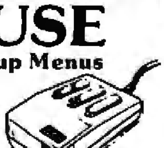

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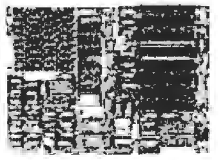

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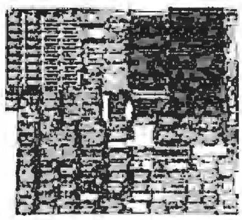

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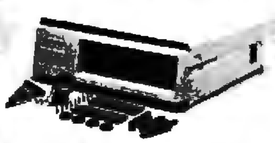

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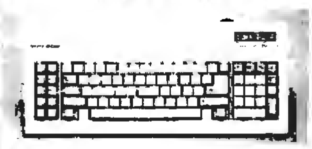

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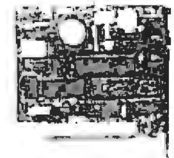

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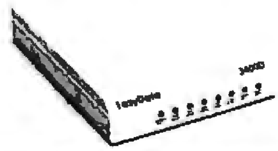

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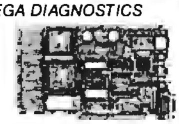

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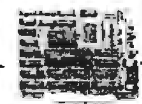

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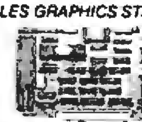

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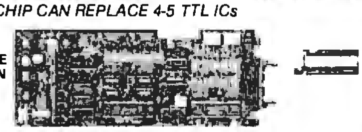

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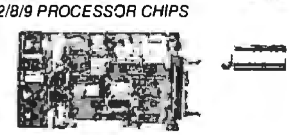

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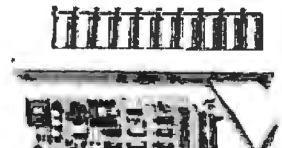

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Inquiry 131

BOMB

YOU CHOOSE THE BEST ARTICLE EACH MONTH

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 in 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.

ARTICLE#	PAGE	ARTICLE	AUTHOR(S)
1	37	Microbytes	staff
2	45	What's New	staff
3	68	Ask BYTE/Circuit Cellar Feedback	Ciarcia
4	81	Book Reviews	Lane, Shammas, Beinhorn
5	101	The New Generation: Under the Covers	Ciarcia
6	113	The New Generation: Head to Head	Vose, Betz, Tazelaar
7	117	Ciarcia's Circuit Cellar: Using the ImageWise Video Digitizer, Part 2: Colorization	Ciarcia
8	123	Creating Fractals	McWorter, Tazelaar
9	135	Inside the 82786 Graphics Chip	Nicholls
10	147	A Prolog Primer	Clocksin
11	161	Simulating a Microprocessor	Lane
12	171	Constraint Logic Programming	Lassez
13	177	Opening the Prolog III Universe	Colmerauer
14	185	Logic Grammars	Szpakowicz
15	201	The Macintosh SE	Loeb
16	207	Two High-Performance PC AT Compatibles	Unger
17	213	80386 Accelerator Boards	Crabb
18	219	Macintosh C Compilers Revisited	West
19	224	386|ASM/LINK 1.1e	Trask
20	229	BackComm and SideTalk	Fixmer
21	232	A CAD for All Incomes	Robinson
22	243	Computing at Chaos Manor: Faster, Bigger, Better	Pournelle
23	257	Focus on Algorithms: Search and Destroy	Pountain
24	263	Applications Only: Moving Toward AI	Shapiro
25	273	Best of BIX	BIXen

BOMB RESULTS

The envelope has been opened, and the results for May are now official. The first-place award goes to Steve Ciarcia. His Circuit Cellar article, "Build a Gray-Scale Video Digitizer, Part 1: Display/Receiver," was a clear winner. The BYTE staff grabs second place for What's New. This month's winner of $100 is John W. Seybold for "The Desktop-Publishing Phenomenon," which chronicled the development of desktop publishing. Jerry Pournelle's column, in which he says "Bye-Bye Big Kat," lands in the fourth position. Very few votes separated the next several places. BYTE staffers Jonathan Erickson, G. Michael Vose, and Charles Weston take fifth for their Product Preview "The Tandon PAC 286." Steve Ciarcia shows up again in sixth for Ask BYTE/Circuit Cellar Feedback. BYTE's Microbytes group, headed by Dennis Barker, takes seventh-place honors. Karl Brown wins $50 for "Build BERT, the Basic Educational Robot Trainer, Part 2." Mr. Brown also wins the $50 bonus award for quality. Congratulations to all.

COMING UP IN BYTE

Features:
The beginning of a three-part series on OS/2, Microsoft's new operating system. Plus features on associative memory, Karmarkar's algorithm, the C++ programming language, and the Turing machine.

Circuit Cellar:
Build your own IBM PC AT clone.

Programming Insights:
Teaching screens new tricks and Ansi.Sys.

Theme:
Printer technologies includes articles on color printing technology, vector-to-raster conversion, page printers, print quality, color thermal transfer technology, hammer bank technology, designing a print head, memory requirements of page printers, and strip buffer technology.

Reviews:
System reviews include the NEC MultiSpeed laptop, the Kaypro 386, and a comparison of the Proteus and PC Designs 12-MHz AT clones. We'll also have a review of the Pixelworks Clipper graphics processor board. Language reviews include ALS Prolog, Actor, and PCMOS. Application reviews are a comparison of dBASE compilers and a look at DESQview 1.3.

And More:
Chaos Manor, Applications Only, Book Reviews, Best of BIX, Microbytes, and What's New.

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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Alphabetical Index to Advertisers

READER SERVICE

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Special Advertising Supplement to U.S. Subscribers
from Priority One Electronics

INTERNATIONAL ADVERTISING SECTION
No domestic inquiries please.

Inquiry No.		Page No.
*	BYTE BITS	64N
*	BYTE MARKETING	64O
*	BYTE SUB. MESSAGE	64M
500	CLUB AT	64B,C
502	COMPUADD	64E
503	COMPUSENSE LTD.	64K
504	CUT PRICE SOFTWARE	64N
505	C.A.S. COMPUTER POINT	64N
506	DIAMOND SOFTWARE	64N
507	EURO-LINK, INC.	64N
508	EXPERT SYSTEMS	64I
509	FORMAT PC	64K
510	GAMMA PRODUCTIONS	64H
511	GREY MATTER	64G
513	JEBAL MICRO SYSTEMS	64K
514	LOGIC PROGRAMMING ASSOC.	64K
515	MAGNETIC MEDIA	64K
526	MAYFAIR MICRO	64P
517	MICROPROCESSOR ENG.	64N
518	M P D ASSOCIATES	64K
527	NOKIA INFO. SYSTEI	64A
519	PB ELECTRONICS	64K
520	RINGDALE PERIPHERALS	64N
*	ROBERT TINNEY GRAPHICS	64L
521	STARTEX	64N
522	TRIANGLE	64K
523	TRYMAX	64N
524	VUMAN COMPUTER SYSTEMS	64K
525	WARREN POINT INT'L LTD.	64J

REGIONAL ADVERTISING SECTION

Greater NYC/Tri-State Area

Inquiry No.		Page No.
401	CARTREX	256A-1
402	CARTREX	256A-1
*	COMPS. FOR THE BLIND	256A-2
403	CTX INTERNATIONAL INC.	256A-4
404	INNOVATIVE DATA TECH.	256A-2
*	MCGRAW-HILL BOOKS	256A-5
405	MEGAHERTZ	256A-7
406	S S E PRODUC	256A-6
407	S T S C	256A-3
408	TRADEWINI LS	256A-6
409	TRI-STATE (	256A-4
410	TIMELINE	256A-8

Southern California
Los Angeles/San Diego

Inquiry No.		Page No.
415	BASIC COMPUTERS	256B-12
416	BYTE & FLOPPY COMP. INC.	256B-12
417	CARTREX	256B-1
418	CARTREX	256B-1
419	COMPUTER APPLICATIONS	256B-12
420	COMPUTER NOOK	256B-12
*	COMPS. FOR THE BLIND	256B-4
421	CTX INTERNATIONAL INC.	256B-6
422	EAGLE ELECTRONICS	256B-6
423	EVERLEAD SYSTEMS, INC.	256B-10
424	INNOVATIVE DATA TECH.	256B-4
426	LASER CONNECTION	256B-7
427	M.A.S. CORPORATION	256B-8,9
428	PC AMERICAN	256B-5
429	QUALITY MICRO	256B-11
430	SOFTWARE MASTERS	256B-3
431	TIMELINE	256B-2

Pacific Northwest

Inquiry No.		Page No.
435	CARTREX	256C-1
436	CARTREX	256C-1
437	COMPONENT SYSTEMS, INC.	256C-6
*	COMPS. FOR THE BLIND	256C-8
438	DIAMOND SOFTWARE	256C-4
439	ELCO COMPUTERS	256C-5
440	KGB ENTERPRISES	256C-2
441	PACIFIC MICRO SYSTEMS	256C-8
442	TATUNG SCIENCE & TECH	256C-6
443	THE PRINTER WORKS	256C-2
444	WHITEWATER GROUP	256C-3
445	TIMELINE	256C-7

Midwest

Inquiry No.		Page No.
451	707 COMPUTER SALES	256D-7
452	ARLINGTON COMPUTER	256D-1
453	CARTREX	256D-3
454	CARTREX	256D-3
*	COALITION FOR LITERACY	256D-8
*	COMPS. FOR THE BLIND	256D-6
455	LEVCO	256D-11
456	LIGHTEK MICROCOMP.	256D-6
*	MCGRAW-HILL BOOKS	256D-12
457	MEDIA SFTW. & SYSTEMS	256D-9
458	M.A.S. CORPORATION	256D-4,5
*	PC LINK	256D-2
459	TIMELINE	256D-10

Southeast

Inquiry No.		Page No.
475	BULLDOG COMPUTER	256E-2,3
476	CARTREX	256E-1
477	CARTREX	256E-1
478	KNAPCO	256E-6
*	MCGRAW-HILL BOOKS	256E-7
479	M.A.S. CORPORATION	256E-4,5
480	TIMELINE	256E-8

Northeast

Inquiry No.		Page No.
465	CARTREX	256F-1
466	CARTREX	256F-1
*	COALITION FOR LITERACY	256F-4
*	COMPUTER MUSEUM	256F-3
467	DEERFIELD DATA SYSTEMS	256F-2
*	MICROMINT	256F-8
*	MCGRAW-HILL BOOK	256F-7
468	ONE D	256F-2
469	TRUE DATA PRODUCTS	256F-5
470	TIMELINE	256F-6

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Enter □□□□□□□□□□ # #

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Enter 1 # 8 7 # #

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

1. □□□ # #	6. □□□ # #	10. □□□ # #	14. □□□ # #
2. □□□ # #	7. □□□ # #	11. □□□ # #	15. □□□ # #
3. □□□ # #	8. □□□ # #	12. □□□ # #	16. □□□ # #
4. □□□ # #	9. □□□ # #	13. □□□ # #	17. □□□ # #
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Index to Advertisers by Product Category

READER SERVICE

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AUGUST
478RSU

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1	23	45	67	89	111	133	155	177	199	221	243	265	287	309	331	353	375	397	419	441	463	485	507	529	551	573	595	617	639	661	683	705	727	749	771	793
2	24	46	68	90	112	134	156	178	200	222	244	266	288	310	332	354	376	398	420	442	464	486	508	530	552	574	596	618	640	662	684	706	728	750	772	794
3	25	47	69	91	113	135	157	179	201	223	245	267	289	311	333	355	377	399	421	443	465	487	509	531	553	575	597	619	641	663	685	707	729	751	773	795
4	26	48	70	92	114	136	158	180	202	224	246	268	290	312	334	356	378	400	422	444	466	488	510	532	554	576	598	620	642	664	686	708	730	752	774	796
5	27	49	71	93	115	137	159	181	203	225	247	269	291	313	335	357	379	401	423	445	467	489	511	533	555	577	599	621	643	665	687	709	731	753	775	797
6	28	50	72	94	116	138	160	182	204	226	248	270	292	314	336	358	380	402	424	446	468	490	512	534	556	578	600	622	644	666	688	710	732	754	776	798
7	29	51	73	95	117	139	161	183	205	227	249	271	293	315	337	359	381	403	425	447	469	491	513	535	557	579	601	623	645	667	689	711	733	755	777	799
8	30	52	74	96	118	140	162	184	206	228	250	272	294	316	338	360	382	404	426	448	470	492	514	536	558	580	602	624	646	668	690	712	734	756	778	800
9	31	53	75	97	119	141	163	185	207	229	251	273	295	317	339	361	383	405	427	449	471	493	515	537	559	581	603	625	647	669	691	713	735	757	779	801
10	32	54	76	98	120	142	164	186	208	230	252	274	296	318	340	362	384	406	428	450	472	494	516	538	560	582	604	626	648	670	692	714	736	758	780	802
11	33	55	77	99	121	143	165	187	209	231	253	275	297	319	341	363	385	407	429	451	473	495	517	539	561	583	605	627	649	671	693	715	737	759	781	803
12	34	56	78	100	122	144	166	188	210	232	254	276	298	320	342	364	386	408	430	452	474	496	518	540	562	584	606	628	650	672	694	716	738	760	782	804
13	35	57	79	101	123	145	167	189	211	233	255	277	299	321	343	365	387	409	431	453	475	497	519	541	563	585	607	629	651	673	695	717	739	761	783	805
14	36	58	80	102	124	146	168	190	212	234	256	278	300	322	344	366	388	410	432	454	476	498	520	542	564	586	608	630	652	674	696	718	740	762	784	806
15	37	59	81	103	125	147	169	191	213	235	257	279	301	323	345	367	389	411	433	455	477	499	521	543	565	587	609	631	653	675	697	719	741	763	785	807
16	38	60	82	104	126	148	170	192	214	236	258	280	302	324	346	368	390	412	434	456	478	500	522	544	566	588	610	632	654	676	698	720	742	764	786	808
17	39	61	83	105	127	149	171	193	215	237	259	281	303	325	347	369	391	413	435	457	479	501	523	545	567	589	611	633	655	677	699	721	743	765	787	809
18	40	62	84	106	128	150	172	194	216	238	260	282	304	326	348	370	392	414	436	458	480	502	524	546	568	590	612	634	656	678	700	722	744	766	788	810
19	41	63	85	107	129	151	173	195	217	239	261	283	305	327	349	371	393	415	437	459	481	503	525	547	569	591	613	635	657	679	701	723	745	767	789	811
20	42	64	86	108	130	152	174	196	218	240	262	284	306	328	350	372	394	416	438	460	482	504	526	548	570	592	614	636	658	680	702	724	746	768	790	812
21	43	65	87	109	131	153	175	197	219	241	263	285	307	329	351	373	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	747	769	791	813
22	44	66	88	110	132	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528	550	572	594	616	638	660	682	704	726	748	770	792	814

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Article No.*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Excellent	1	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97
Good	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98
Fair	3	7	11	15	19	23	27	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	95	99
Poor	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100

Article No.*	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Excellent	101	105	109	113	117	121	125	129	133	137	141	145	149	153	157	161	165	169	173	177	181	185	189	193	197
Good	102	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	194	198
Fair	103	107	111	115	119	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199
Poor	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200

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7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify)

B. How many people does your company employ?
1. ☐ 1–49
2. ☐ 50–999
3. ☐ 1,000 or more

C. Information requested for:
1. ☐ Business use
2. ☐ Personal use
3. ☐ Both

D. Do you plan to purchase items inquired about within:
1. ☐ Next 3 months?
2. ☐ Next 6 months?
3. ☐ Next 12 months?

E. Please check the statement that best describes your involvement in your company's purchasing decisions. (Check all that apply.)
1. ☐ I determine the need
2. ☐ I evaluate products/systems
3. ☐ I select/recommend the vendor
4. ☐ I approve/authorize the purchase

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2	24	46	68	90	112	134	156	178	200	222	244	266	288	310	332	354	376	398	420	442	464	486	508	530	552	574	596	618	640	662	684	706	728	750	772	794
3	25	47	69	91	113	135	157	179	201	223	245	267	289	311	333	355	377	399	421	443	465	487	509	531	553	575	597	619	641	663	685	707	729	751	773	795
4	26	48	70	92	114	136	158	180	202	224	246	268	290	312	334	356	378	400	422	444	466	488	510	532	554	576	598	620	642	664	686	708	730	752	774	796
5	27	49	71	93	115	137	159	181	203	225	247	269	291	313	335	357	379	401	423	445	467	489	511	533	555	577	599	621	643	665	687	709	731	753	775	797
6	28	50	72	94	116	138	160	182	204	226	248	270	292	314	336	358	380	402	424	446	468	490	512	534	556	578	600	622	644	666	688	710	732	754	776	798
7	29	51	73	95	117	139	161	183	205	227	249	271	293	315	337	359	381	403	425	447	469	491	513	535	557	579	601	623	645	667	689	711	733	755	777	799
8	30	52	74	96	118	140	162	184	206	228	250	272	294	316	338	360	382	404	426	448	470	492	514	536	558	580	602	624	646	668	690	712	734	756	778	800
9	31	53	75	97	119	141	163	185	207	229	251	273	295	317	339	361	383	405	427	449	471	493	515	537	559	581	603	625	647	669	691	713	735	757	779	801
10	32	54	76	98	120	142	164	186	208	230	252	274	296	318	340	362	384	406	428	450	472	494	516	538	560	582	604	626	648	670	692	714	736	758	780	802
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14	36	58	80	102	124	146	168	190	212	234	256	278	300	322	344	366	388	410	432	454	476	498	520	542	564	586	608	630	652	674	696	718	740	762	784	806
15	37	59	81	103	125	147	169	191	213	235	257	279	301	323	345	367	389	411	433	455	477	499	521	543	565	587	609	631	653	675	697	719	741	763	785	807
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17	39	61	83	105	127	149	171	193	215	237	259	281	303	325	347	369	391	413	435	457	479	501	523	545	567	589	611	633	655	677	699	721	743	765	787	809
18	40	62	84	106	128	150	172	194	216	238	260	282	304	326	348	370	392	414	436	458	480	502	524	546	568	590	612	634	656	678	700	722	744	766	788	810
19	41	63	85	107	129	151	173	195	217	239	261	283	305	327	349	371	393	415	437	459	481	503	525	547	569	591	613	635	657	679	701	723	745	767	789	811
20	42	64	86	108	130	152	174	196	218	240	262	284	306	328	350	372	394	416	438	460	482	504	526	548	570	592	614	636	658	680	702	724	746	768	790	812
21	43	65	87	109	131	153	175	197	219	241	263	285	307	329	351	373	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	747	769	791	813
22	44	66	88	110	132	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528	550	572	594	616	638	660	682	704	726	748	770	792	814

BYTE's ongoing monitor box (BOMB) lets you rate each article you've read in BYTE as excellent, good, fair, or poor. Each month, you can mail in the BOMB card found at the back of each issue. We tally your votes, total the points, tell you who won, and award the two top-rated nonstaff authors $100 and $50, respectively. An additional $50 award for quality goes to the nonstaff author with the best average score (total points divided by the number of voters). If you prefer, you can use BIX as your method of voting. We welcome your participation.

Article No.*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Excellent	1	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97
Good	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98
Fair	3	7	11	15	19	23	27	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	95	99
Poor	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100

Article No.*	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Excellent	101	105	109	113	117	121	125	129	133	137	141	145	149	153	157	161	165	169	173	177	181	185	189	193	197
Good	102	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	194	198
Fair	103	107	111	115	119	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199
Poor	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200

*To determine this month's Article No., see BOMB as listed in Table of Contents under Departments.

Name ____________
Title ____________
Company ____________
Address ____________
City ____________
State ________ Zip ________
Telephone ____________

A. What is your principal occupation? (Please check one only.)
1. ☐ Business Owner
2. ☐ Manager/Administrator
3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify)

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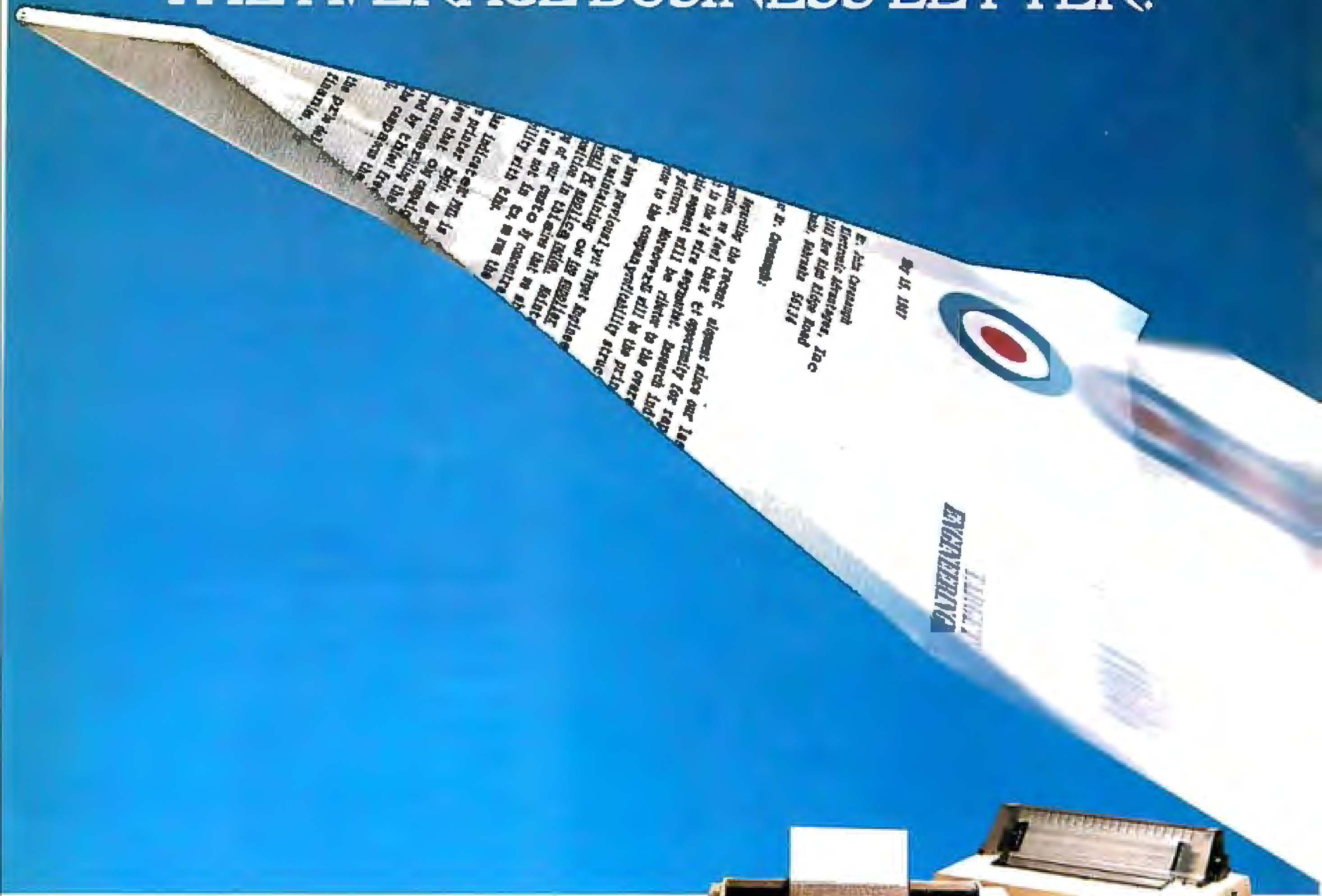
INTRODUCING THE PINWRITER P9XL. YOU WON'T BELIEVE WHAT IT DOES TO THE AVERAGE BUSINESS LETTER.



Fasten your seatbelts. The new Pinwriter® P9XL printer from NEC is about to take off.

It cruises at 400 characters per second in draft mode, 140 characters per second in letter quality mode. Which means it can really make those business letters fly. In fact, no other 24-pin printer is faster.

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It's our fastest
printer yet.
```

Actual print sample from the Pinwriter P9XL printer.

NEC PRINTERS. THEY ONLY STOP WHEN YOU WANT THEM TO.

And because it uses a 24-pin printhead and a multistrike film ribbon—the same kind that's used in typewriters and letter-quality printers - the P9XL also delivers better print quality than its competitors. It even prints in color.

But it's not limited to letters. The Pinwriter P9XL is a true multi-purpose printer that can fly through payroll, invoices, continuous forms, multi-part forms—just about any business or office application.

Best of all, it's from NEC—the world's largest manufacturer of 24-pin printers. The company that consistently offers you the highest reliability ratings in the industry. (You can expect your P9XL to run for five years before it might need a repair.)

So don't waste any more time. Fly down to your nearest dealer and ask to see the new Pinwriter P9XL. Or call NEC at 1-800-343-4418 (in MA, (617) 264-8635). Or if you prefer, write to NEC Information Systems, Dept. 1610, 1414 Massachusetts Ave., Boxborough, MA 01719.

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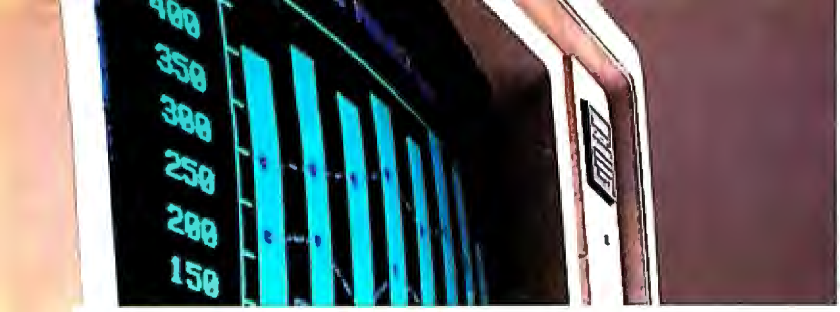
Inquiry 183



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Get total control plus power protection for only $79.95

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In addition, you get full power-line noise filtration, plus full common and differential mode spike protection. This reduces the chance of file damage or "glitches" caused by common voltage spikes. For more protection, the system includes a circuit breaker.

The Power Switching System acts as a monitor base, and even swivels to provide the best viewing angle. To give you added flexibility, there's a long-reaching 10-ft. power cord.

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