BYTE

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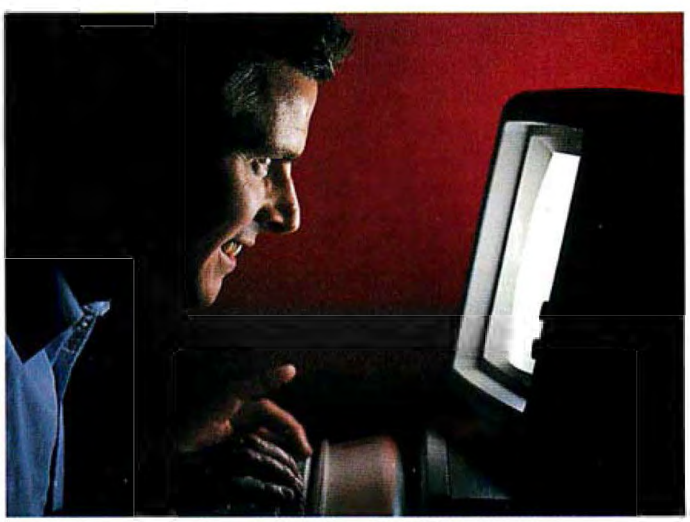
Tandy's New Lineup

THEME
Heuristic Algorithms

Turbo C, Turbo Basic, Turbo Pascal and Turbo Prolog: technical excellence



"Borland International's Turbo Pascal, Turbo Basic and Turbo Prolog automatically identify themselves, by virtue of their 'Turbo' forenames, as superior language products with a common programming environment. The appellation also means to many PC users a 'must have' language. To us Turbo C looks like a coup for Borland.

Garry Ray, PC Week"

B1-1131A

Turbo Basic introduces its powerful new Telecom, Editor and Database Toolboxes

NEW!

Turbo Basic® is the breakthrough you've been waiting for. The same power we brought to Pascal with Turbo Pascal has now been applied to BASIC with Turbo Basic.

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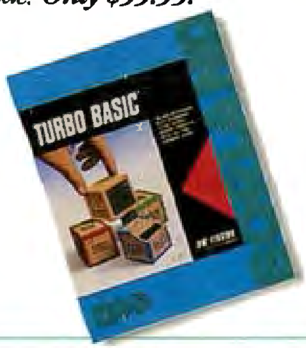

A technical look at Turbo Basic

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- ☑ Full 80-bit precision
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- ☑ Full window management

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> *Ethan Winer, PC Magazine*

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Source code included.

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Includes source code.

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Turbo Prolog: The Natural Language of Artificial Intelligence

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Turbo Prolog's development system includes:

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- ☑ A full-screen interactive editor.
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Turbo Prolog offers generally the fastest and most approachable implementation of that language."

Darryl Rubin, AI Expert

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Tur
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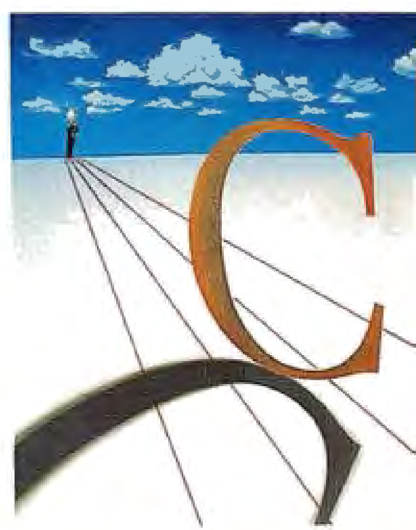

"Turbo C does look like What We've All Been Waiting For: a full-featured compiler that produces excellent code in an unbelievable hurry . . . moves into a class all its own among full-featured C compilers . . . Turbo C is indeed for the serious developer . . . One heck of a buy—at any price."

Michael Abrash, Programmer's Journal

bo C: NEW!
'erful optimizing
ler ever

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).
- ☑ Interactive Editor: The system includes a powerful, interactive full-screen text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code.
- ☑ Development Environment: A powerful "Make" is included so that managing Turbo C program development is highly efficient. Also includes pull-down menus and windows.
- ☑ Links with relocatable object modules created using Borland's Turbo Prolog into a single program.
- ☑ Inline assembly code.
- ☑ Loop optimizations.
- ☑ Register variables.
- ☑ ANSI C compatible.
- ☑ Start-up routine source code included.
- ☑ Both command line and integrated environment versions included.
- ☑ License to the source code for Runtime Library available.

Join more than 100,000 Turbo C enthusiasts. Get your copy of Turbo C today!

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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Why more than 600,000 programmers worldwide are using Turbo Pascal today

The irresistible force behind Turbo Pascal's worldwide success is Borland's advanced technology. We created a compiler so fast, that Turbo Pascal® is now the worldwide standard. And there are more tools for Turbo Pascal than for any other development environment in the world.

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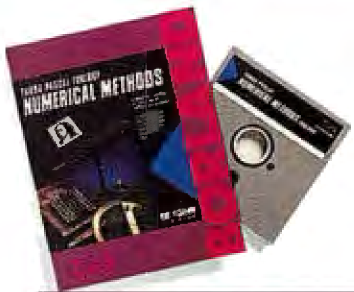
 and our newest,
- Numerical Methods Toolbox™

And because Turbo Pascal is the established worldwide standard, 3rd party, independent non-Borland developers also offer an incredible array of programs for Turbo Pascal. ***Only $99.95!***

> "Borland International's Turbo Pascal took the programming world by storm. A great compiler combined with a good editor at an astounding price, the package quickly came to be called, simply, Turbo—and has sold more than 500,000 copies.
>
> *Stephen Randy Davis, PC Magazine*
>
> Language deal of the century. *PC Magazine*"



For Scientists and Engineers: Turbo Pascal Numerical Methods Toolbox

The Numerical Methods Toolbox is a complete collection of Turbo Pascal routines and programs. Add it to your development system and you have the most comprehensive and powerful numerical analysis capabilities—at your fingertips!

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- ☑ Matrix Eigenvalues
- ☑ Differential Equations
- ☑ Least Squares
- ☑ Fourier Transforms
- ☑ Graphics

Each module comes with procedures that can be easily adapted to your own program. The Toolbox also comes complete with source code. So you have total control of your application.

Only $99.95! BI-1131A

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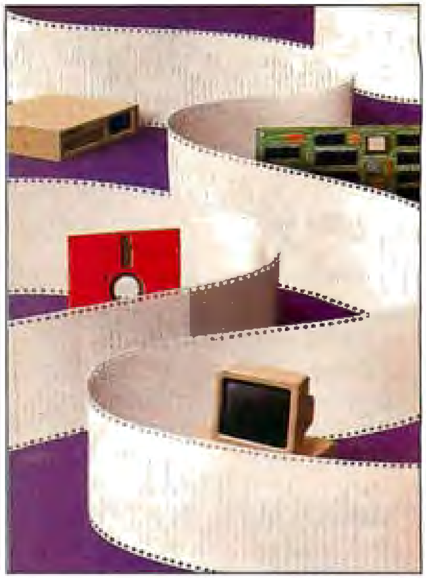

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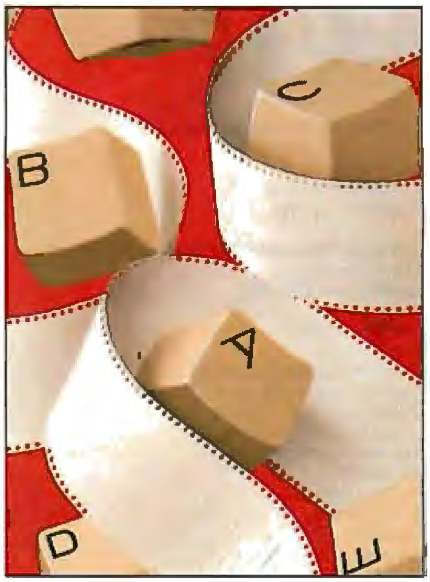

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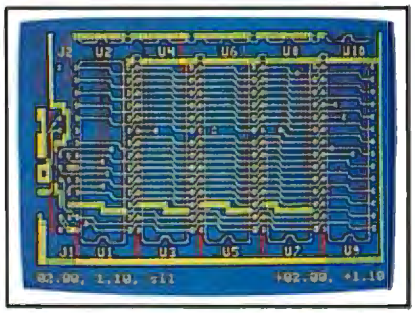

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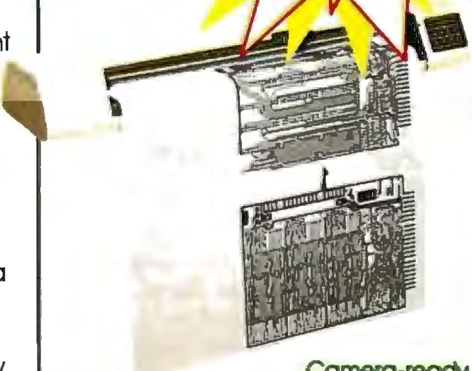

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- ☐ IBM Graphics Printer or Epson FX/MX/RX-series printer, and/or
- ☐ Houston Instrument DMP-40, 41, 42, 51, 52, or Hewlett-Packard 7470, 7475, 7550, 7580, 7585, 7586 pen plotter
- ☐ Optional Microsoft Mouse

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BIX's New Pyramid 9820

The BIX community, which numbers more than 17,000 users, can now get much bigger because a larger and faster computer is going on-line. Our Pyramid 9820, as delivered, will support 224 simultaneous BIX users and can expand to support at least 350 users. In our simulations, the Pyramid 9820 ran the BIX conferencing software with very fast response times—even under peak user loads.

We could also expand our system by adding more processors to support a much larger number of users. If we ever exceed the capacity of one Pyramid, further expansion is possible by networking multiple Pyramids with NFS, the network file system developed by Sun.

We considered several good contenders for the role of BIX host. The Pyramid 9820 won because it gives us, in addition to high performance and cost-effectiveness, the reassurance that comes with seeing every essential feature already working at the time of purchase.

System Specifics

Our new Pyramid 9820 computer has dual 32-bit processors based on a RISC (reduced instruction set computer) architecture and runs the OSx operating system; this is Pyramid's way of simultaneously supporting both Berkeley 4.2 BSD and System V versions of Unix. While the Pyramid 9820 can have as much as 128 megabytes of RAM, ours has "only" 32 megabytes. Each of the Pyramid CPUs has 528 registers.

The Pyramid 9820, which has a system computation of 13 million instructions per second, can be upgraded to a three-processor 9830 or a four-processor 9840. These upgrades would increase system computation to 19 and 25 MIPS, respectively, according to Pyramid.

The RISC CPUs execute most instructions in a single 100-nanosecond cycle. Each CPU has its own 16K-byte instruction cache and 64K-byte data cache in order to reduce memory-access time. Floating-point processors are included in each CPU.

Pyramid's multiprocessor architecture is symmetrical. That is to say, neither processor is master or slave—each can execute both system and user tasks, so that a new task goes to the next available processor. Both CPUs share a single copy of the Unix kernel. In our previous BIX system, performance was at times constrained because even though four 68020s were all functioning as CPUs, only one of them could run Unix kernel tasks.

Input/Output

I/O performance is critical in an application like BIX. The CPUs and terminal processors in the Pyramid 9820 communicate over a 40-megabyte-per-second 32-bit system bus called the XTEND bus. In addition to two terminal processors with asynchronous ports, our Pyramid 9820 has two synchronous X.25 processors, each of which can handle up to 56K bits per second. The intelligent I/O processor in the Pyramid 9820 uses an AMD 29116 processor and 14 parallel direct-memory-access channels, with a bandwidth of 5 megabytes per second per channel. Pyramid says the aggregate I/O throughput is 11 megabytes per second per I/O subsystem. We ordered the 9820 with two I/O subsystems installed.

Since conferences reside on disks, BIX performance depends on fast disk I/O. The Pyramid 9820 and its I/O subsystem use the ESMD disk interface to transfer data at up to 2½ megabytes per second, using overlapping seeks and rotational position sensing to increase the rate of transactions.

System Software

Pyramid's dual-port OSx operating system provides both major Unix standards concurrently: Berkeley 4.2 BSD and AT&T System V. We're running CoSy under System V. The most remarkable thing about Pyramid's implementation of Unix is that it enables the CPUs to operate symmetrically and to share the burden of the Unix kernel. The tasks handled by the kernel are, of course, vital to system performance, including handling of interrupts and of system calls.

By Pyramid's estimate, a master-slave dual processor is limited in performance to about 1.5 times the performance of a single-processor system. The symmetrical implementation of dual processors, according to Pyramid, boosts the performance of two processors to 1.85 times that of a single processor. Moreover, Pyramid 9000 family systems like the 9820 can be upgraded to as many as four CPUs, with all of them sharing system and user tasks.

Pyramid's version of Unix implements virtual memory with demand paging, to provide 4 gigabytes of directly addressable memory space for each Unix process. Pages are 2K bytes each. The file system has a 2K-byte physical-block size and an 8K-byte logical-block size. The Pyramid version of Unix supports all the features of the Berkeley 4.2 BSD Fast File System to provide faster storage and retrieval. Programs written for System V. can take advantage of the Berkeley Fast File System.

Pyramid also has a virtual disk facility that is part of OSx. The virtual disk permits concatenation of multiple partitions into a single large file system. Disk partitions can be larger than the largest physical disk. In addition, the virtual disk facility permits "striping" of virtual disk files. A striped disk is made up of two or more pieces of one or more physical devices. The striped file uses an interleaving algorithm to translate block numbers of the logical disk into those of the physical disk. The result is that files can be striped across multiple disks to achieve greater system I/O throughput because I/O activity is distributed evenly across several drives or controllers.

The variety of possibilities for data storage should allow us to get the most out of the Pyramid hardware. We'll begin with four 470-megabyte disk drives.

Summing Up

The Pyramid 9820 gives us enough computing power, ports, and X.25 virtual connections to support hundreds of simultaneous users and also to arrange data feeds for additional information products to be accessible to BIX users. We will be not only improving service for users of BIX conferences and the Microbytes news service, but also making the entire BIX environment richer.

We are confident that the Pyramid 9820 architecture will provide a fine venue for sophisticated computer users all over the world to "meet" on-line for years to come. We look forward to seeing you there.

—Phil Lemmons
Editor in Chief
(BIX name: "plemmons")


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LETTERS

and Review Feedback

Enhancements to C-terp

I was extremely pleased by John Unger's favorable review of C-terp ("Four C Language Interpreters," June). His description of C-terp is accurate, and his understanding of the product is excellent.

I would like to update readers on Gimpel Software's C-terp 3.00. We have added numerous debugging features, including the dumping of aggregates such as structures and arrays, exposed macros, watch expression, watch condition, sticky breakpoints, temporary breakpoints, and a `leave function` command.

Gimpel Software has developed a new optional method of handling very large applications by having all C modules share the same external symbol table. In addition to saving on space, this option also speeds up compilation. Another enhancement is C-terp's ability to directly access extended memory through software paging. We now provide an automated system of adding commercial libraries by running a simple batch procedure. Also, a new configuration program lets users more easily customize C-terp to their personal programming habits and particular applications.

James F. Gimpel
President, Gimpel Software
Collegeville, PA

Of Mice and Mechanics

The review of computer mice by William H. Murray and Chris H. Pappas ("Pick of the Litter," June) was, in our opinion, not a thorough investigation of issues that are relevant to everyday use of the device. Specifically, we at the Torrington Company do not agree with the statements about our two-wheel direct drive tracking mechanism, nor do we believe them to be a concern of the typical user. It has been our experience that the two-wheel design works well on many different surfaces, both hard and soft, and we've received very few customer complaints regarding this issue.

Additionally, the reviewers made a statement about the trouble-free operation of optical versus mechanical mice because of the clogging associated with "wheels and balls." It was our recognition of this problem that led us to use the wheel design. We are sure that if the reviewers had sufficient time to thoroughly test this design compared to a traditional ball mouse, they would agree that it will not clog with normal use.

Finally, the statement regarding our Model 1001C-KF (and the Keyfree driver) is incorrect. Keyfree will not allow the user to "custom-design application-dependent pull-down menus." Instead, we provide a pop-up window to allow redefinition of mouse buttons while in the application program.

Mark J. Rossi
The Torrington Company
Torrington, CT

Updating Ada

I commend you and Namir Clement Shammas on the excellent comparative review of PC Ada compilers ("Ada Moves to Micros," July). Since the review appeared, Artek Ada has been greatly enhanced. the current version number is 1.30, and this new release now supports complete Ada tasking, generic objects, and all the features listed in table 1 on page 240 of the July issue. The Artek translator now handles all BYTE benchmark programs correctly, and, according to our tests, the compiler now performs better in the speed and executable file size benchmarks.

Artek Ada has been scheduled for official validation at the British National Computing Centre this autumn. We expect the certified Artek Ada 2.0 to be commercially available later this year. The price of the compiler will remain at $495. An upgrade from the previous versions will be available at a nominal charge.

Finally, we've moved, and our address is now Artek Corp., 835 East 25th Ave., Eugene, OR 97405. The local phone number is (503) 683-1265. Our toll-free number remains (800) 722-7835.

Vilhjalmur Thorsteinsson
Manager, Research and Development
Artek Corporation
Eugene, Or

Namir Clement Shammas states that Alsys Ada "dictates that you use the Profit board; it will not run without it, and it will not run with any other memory board." This is completely incorrect! Alsys Ada version 1.2 works with as little as 3 megabytes of memory from any memory board. You must set certain switches on the Alsys compiler, since it expects 4 megabytes, but it works well with 3 megabytes.

Also, although Alsys Ada requires compiling on an IBM PC AT, compiled programs will run on IBM PCs or compatibles. Thus, you can develop programs on an AT and port them for PC, XT, and AT users.

William H. Murray
Montrose, PA

Mac II Preview

I used to say that I subscribed to BYTE to read Jerry Pournelle's column. After a couple of readings of your April issue (specifically the product preview of the Apple Macintosh II), I have to add two names: Gregg Williams and Tom Thompson. Really, a great article.

The article, however, leaves an unanswered question. In which BYTE issue will we get a Macintosh II product review?

Thanks for a fine job.

David E. Goode
McLean, VA

Thank you. A review of the Macintosh II appears on page 197.

—Eds.

Noted with Interest

The articles in your May issue were interesting and informative—in particular, the features about desktop publishing.

I noted with regret, however, the lack of any discussion about Page Planner in the text of Thom Holmes's article, "Make My Page." We operate three Page Planner units in our shop and consider them to be excellent. Moreover, the new owners of the supplying company have an aggressive development program under

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.

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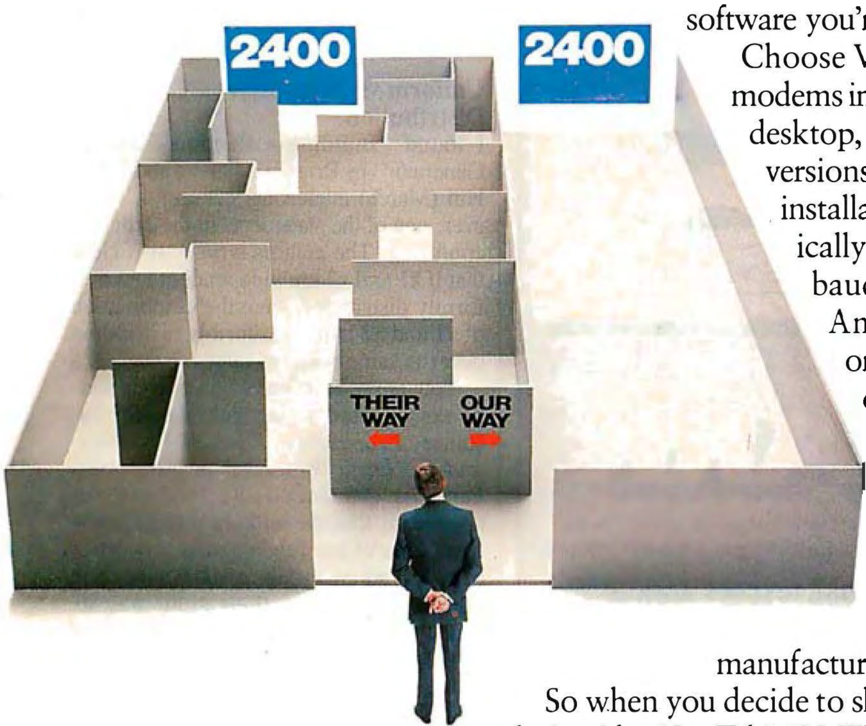

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way, and we are very pleased with the range of new products.

I draw this to your attention because we rely on your publication to be thorough, and to discover the "sleepers" for us. If we relied on Mr. Holmes's article while shopping for a microcomputer-based typesetter, we would have missed Page Planner, and that would have been a shame.

For many (if not most) applications, Page Planner can match Magnatype feature for feature—that is, in every way except price. With certain subroutines Magnatype is vastly superior, of course; with others, such as the Universal Conversion, Magnatype remains in the Stone Age in comparison. But again, Page Planner costs significantly less.

Paul Davies
Oakville, Ontario, Canada

Uniform vs. Nonuniform Distribution

I found "Building a Random-Number Generator" by Brian Wichmann and David Hill (March) interesting and useful. However, one of the statements in the article is confusing. The authors write, "It is clear that if $x1$ and $x2$ are independent and uniformly distributed, then the combination of $x1$ and $x2$ is also uniformly distributed over the same range of values."

You can refer to one of numerous textbooks devoted to the subject—for instance, *Probability, Random Variables, and Stochastic Processes* by Athanasios Papoulis (McGraw-Hill, 1965)—to be convinced that the authors' claim is not true. One of the fundamental properties of two random variables states that their combination (i.e., their sum) has its probability density function in the form of the convolution of the primary probability density functions. In the referred case, for $x1$ and $x2$ uniformly distributed over the range (0,1), the combination $x1+x2$ will be nonuniformly distributed (triangle-shaped) over the range (0,2).

Roman A. Dyba
Rome, Italy

A Powerful Idea

Bill Gates's article, "Beyond Macro Processing," in the Summer *Applications Software Today* issue of BYTE, calls for a common application protocol that would provide a programmatic interface to the functions of multiple applications, to supplement the user interfaces for these functions. This would permit the creation of useful macro programs that combine and integrate the functions of several applications, using a standard macro language.

This is a powerful idea, and it is en-

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Corporate Headquarters: 3243 Sunset Boulevard • West Columbia, South Carolina 29169 • 803/796-7800 • TWX 510-601-2645 couraging to see the head of a major software company advocate it in such convincing detail. But it is not an entirely new idea (in the mainframe and minicomputer arenas, IBM's Rexx and Exec2 languages and the various Unix shell languages are macro languages in Gates's sense), and it has some clear limitations.

Application commands sometimes have many relevant outcomes, each of which must be dealt with in the macro program. Too often, though, sophisticated pattern-matching is needed to distinguish these outcomes. This greatly complicates the task of writing nontrivial macro programs. Moreover, changes to the underlying applications can change both the outcomes and their distinguishing patterns, thus invalidating existing macro programs.

It is possible to overcome these problems by designing and maintaining application commands as if they were programming language statements or library subroutines, but this may be asking too much of application developers.

Chris Shaw
Manhattan Beach, CA

Contouring Comments

Paul D. Bourke's article and accompanying software code, "A Contouring Subroutine" (June), is a fine example of the kind of material that I believe is worthy of being published in BYTE. Bourke writes with clarity, and his descriptions are precise; this applies to both text and software.

About 12 years ago, as part of a commercial venture, I wrote a subroutine similar to Bourke's CONREC, and I agree with him that other, commercially available contouring subroutines are needlessly complex and computationally intensive. In my own subroutine, the common apex of the triangles whose planes intersect (or do not intersect) the plane of a specified contour level are the "centers of gravity" of groups of two, three, or four contiguous points. The professional geographer who reviewed my work objected that it was too simple a scheme to be of any real value.

I am less enthusiastic about William G. Hood's article, "Polynomial Curve Fitter," in the same issue. The article assumes that the user knows virtually nothing about the mathematical bases on which the curve-fitting algorithm is built, and this is glossed over in the article by superficial descriptions of the mathematics involved. This is an increasingly common treatment of programs using the techniques of numerical analysis, and there have been several descriptions in the literature of indiscriminate use of such routines as if they were universal tools.

Hood asserts that "the program . . . uses the orthogonal polynomial method," as if there were only one such method and as if there were only one form of orthogonal polynomial. In fact, with all weight factors equal to 1, Hood's scheme is nothing more than ordinary polynomial regression. In addition, there are numerous orthogonal polynomials, and these include the Fourier series (touched on lightly in Hood's article), which has the unique property of being dually orthogonal.

Hood also errs in limiting his description of Horner's rule for evaluating polynomials. The procedure requires n multiplications plus n additions for a total of $2n$ operations. For values of $n \leq 4$, Horner's rule requires the minimum possible number of arithmetic operations, but for polynomials of higher degree, there are schemes that require fewer than $2n$ operations.

I suppose it is natural that we "old fogies" of the precomputer generation should note that Horner's rule did not magically appear in the BASIC language, and that there are implementations of the rule other than the one presented in Hood's article. Using the more accepted form of Hood's polynomial; that is,

$$p(x) = c_0 + c_1x + c_2x^2 + \ \ldots \ c_nx^n,$$

Horner's rule requires the forming of the nested arrangement,

$$p(x) = c_0 + x(c_1 + x(c_2 + \ \ldots \ x(c_{n-1} + xc_n) \ \ldots \ ))$$

If the order of the terms on the right-hand side is reversed, the nested form can be more readily understood, and for a polynomial of degree 5 (for example) we get

$$p(x) = ((((c_5x + c_4)x + c_3)x + c_2)x + c_1)x + c_0$$

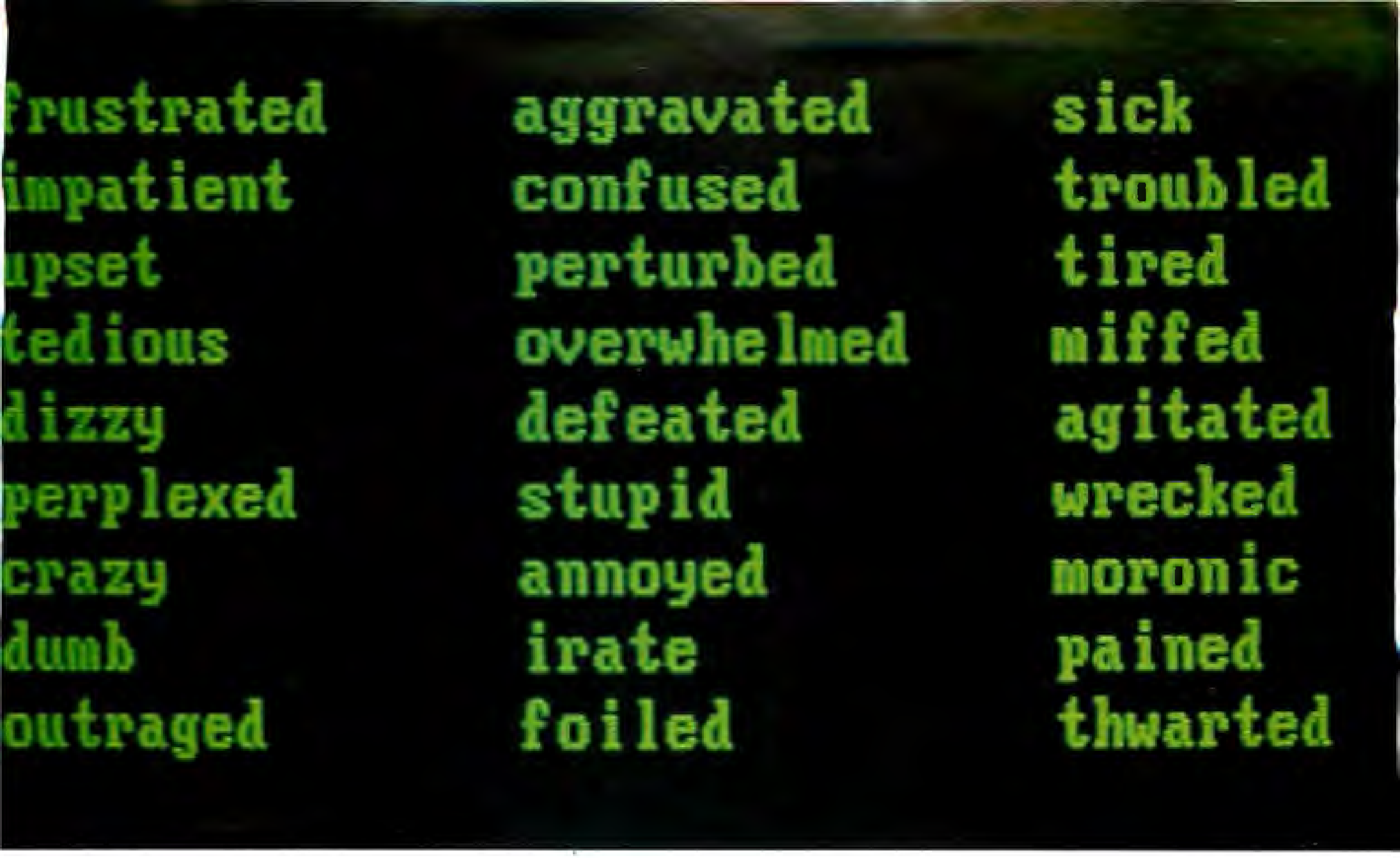
It should also be emphasized that the range of validity of the regressed polynomial expression is limited to the range of the empirical data; in Hood's example, $0.5 < x < 15.5$.

Clive J. Grant
Chichester, NH

Accurate Algorithm

I would like to offer some comments on Paul D. Bourke's interesting article, "A Contouring Subroutine," (June). The main strength of the algorithm Bourke presents (other than sheer simplicity) is its high degree of accuracy, especially in those cases where the data points are chosen judiciously. It will not produce intersecting contour lines, an anomoly

continued



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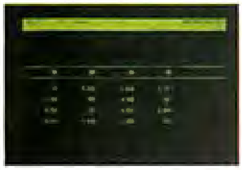

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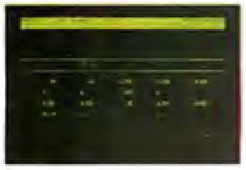

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often allowed by more "advanced" contouring packages in which each contour is smoothed independently of its neighbors. It also produces a more straightforward representation of edge discontinuities.

The problem of the lack of z-value information is actually worse than the article implies, however, as it is not possible to determine direction of slope or to distinguish between bumps and dents. In addition to the visual clues mentioned (color, line style, and contour labeling), I have found that viewpoints other than the vertical provide a depth clue readily apparent to most eyes, even without hidden-line removal.

A weakness not mentioned in the article is that contours drawn within one grid square are not influenced by nearby trends. For example, the algorithm will produce the same (incorrect) saddle shape for a grid element crossed by a ridge along one diagonal or by a valley along the other diagonal. This problem disappears when data points are spaced closely enough to minimize the out-of-plane warping of each grid element.

The CONREC subroutine operates on a grid formed by the intersection, at right angles, of two sets of irregularly spaced parallel lines.

Of course, quadrilaterals of extremely irregular shape should probably be handled more generally, perhaps by calculating the z value of the central point as an average weighted by the relative lengths of the diagonals. In addition, where the central point falls outside of the element, the shorter diagonal should be used to divide the quadrilateral into just two triangles.

In any case, it seems futile to resolve the results calculated on a typical finite element mesh, in which element sizes often vary widely, onto a regularly spaced grid for the sole purpose of producing a contour plot. In addition, contour-smoothing algorithms are based on interpolation techniques that bear no relationship to the laws actually governing the behavior of the structure being analyzed.

While the mathematics of the algorithm itself are quite simple, I found Mr. Bourke's implementation unnecessarily complicated. Each triangle is classified according to the relative positions of each of its vertices below, coincident with, or above each contour plane. A simpler approach uses these three rules:

Rule 1. If the number of contour planes below each vertex of a triangle is the same, the triangle is not intersected by any of them.

Rule 2. If a triangle is intersected by any contour planes, then at least one of its sides will be intersected by each of the resulting contour lines, and this side will be one that connects vertices having the minimum and maximum z coordinates.

Rule 3. Each contour line will also intersect one of the two remaining sides, depending on whether its z coordinate is less than that of the third vertex.

Note that if two vertices have an identical z coordinate, then either of the two sides qualifying under Rule 2 can be chosen with no adverse results. Coding this approach is further simplified by the fact that only two cases are considered, and if contours are processed in order of z coordinate, all of one type (i.e., below the third vertex) are calculated before any of the other type. Mr. Bourke's various triangle classification schemes are handled properly, but without having to consider them as special cases:

1. All vertices below or above a given contour plane: This plane is not considered with respect to this triangle (rule 1).

continued

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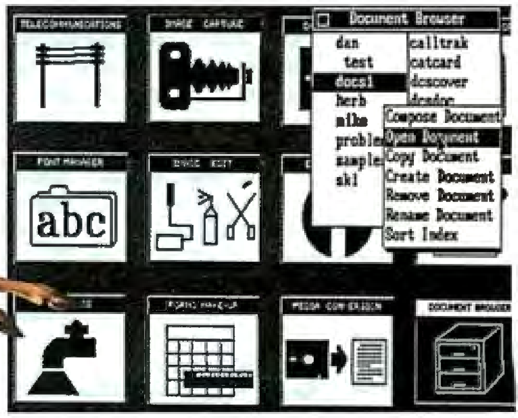
On a project commissioned by NASA, Dr. Christine Mitchell at the Georgia Institute of Technology, chose to use Smalltalk/V as an integral part of a new man-machine interface. The application, written in Smalltalk, continually monitors the commands of the Satellite Network Operator, the state-of-the-network and the overall mission plans. To NASA, Smalltalk/V means real-time. Real OOPS. Real results.



It's tracking white-tail deer on the Barrier Islands of Georgia.

Dr. Lee Graham, a National Park Service ecologist chose Smalltalk/V to write an application to help manage the white-tail deer population on the Barrier Islands of Georgia. Dr. Graham found that Smalltalk/V, with its visual interface and class structure, is a perfect tool to graphically simulate the complex, ecological interactions of natural systems.

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2. All vertices coincident with the given contour plane: No contours cross this triangle (rule 1).
3. Vertex *a* coincident with the contour plane, with *b* and *c* both above or both below: A zero-length line is drawn at *a*.
4. Vertices *a* and *b* coincident with the contour plane: A line is drawn beside *ab*.
5. Vertex *a* below the contour plane, and vertices *b* and *c* above (or the reverse): A line is drawn connecting sides *ab* and *ac*.
6. Vertex *a* above the contour plane, *b* below, and *c* coincident: A line is drawn from a point on line *ab* to vertex *c* (which can be assumed to belong either to side *ac* or to side *bc* with no change in result).

Al Dunbar
Edmonton, Alberta, Canada

Evaluating Benchmarks

In "The New Generation: High-Tech Horsepower" (July), a benchmark comparison between the iAPX386 and the MC68020, you took pains to explain that benchmarks, especially those written in high-level code and that run on off-the-shelf machines, present a can-of-worms problem and are likely to be misleading in that they test the compiler and the whole system perhaps more than the central processor itself. Without quoting figures from my own experimentation and analysis, I would like to point out that the results you presented at the end of the article are indeed misleading, just as you hint they may be.

The choice of systems on which to perform the tests is fair to neither CPU, and disproportionately so. A Sun-3 system and Sun's compiler would make vastly better use of the 68020; systems and compilers yet to be developed using the 80386 would do more justice to it.

The only way to obtain a valid comparison between anything is to isolate the objects in question from all other factors, removing unrelated variables from the equation. To realistically compare the 80386 to the 68020, experts for each system would have to hand-optimize the code for each benchmark, then run the test on a system designed to perform at the maximum possible speed for each chip, under the stated conditions (i.e., floating-point processor or not, memory management or not, and so forth), and run each test to its completion rather than extrapolating from a subsample.

To date, all published "benchmark" tests I have seen concerning these two CPU chips, yours included, fail to isolate the variables under test from the noise, and therefore they say little or nothing about the actual performance of the CPUs in question.

Ian H. Merritt
Oxnard, CA

The July article entitled "The New Generation: High-Tech Horsepower" gives a very misleading impression of floating-point performance on the Macintosh.

The confusion arises because you have naively used double variables in your tests; the more accurate 80-bit extended format is the natural format for the SANE floating-point package. I believe double and single variables are supported only to enable data transfer to other computers that use these formats. All computations should be done using extended variables; otherwise, the computer spends an enormous amount of time converting to and from different floating-point formats because all internal computations are done in extended format.

For example, your Float test in Tom M. Leonard Pascal version 2.01 takes 126 seconds on my humble Mac Plus using extended variables in extended precision, while it takes an amazing 276 seconds using double variables in double precision.

Using a good C compiler on a Mac SE

continued

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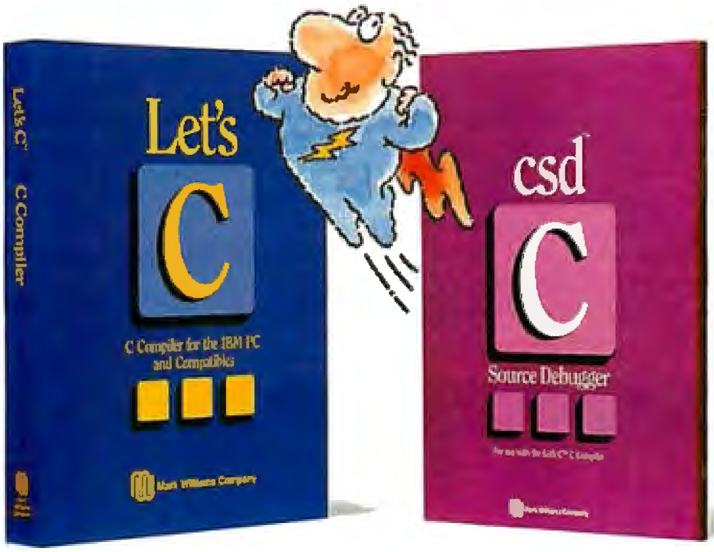

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with extended variables, you will comfortably out-perform an IBM PC AT without floating-point unit and be more accurate at the same time.

I hope you will publish the list of benchmark results again, but this time using extended variables on the Mac. I do not believe it is performing any trick against the spirit of benchmarking to artificially boost the performance of the Mac. After all, you are requiring greater accuracy and simply using the format it was designed for, and using double variables artificially degrades its performance. Also, I suspect that floating-point software for the other computers is designed for double variables.

K. D. Watling
Swansea, Wales

I would like to make two suggestions that would enhance the value of future 32-bit benchmarks. The first regards 32-bit versus 16-bit benchmarks; the second, register variables.

I believe that the benchmarks for 32-bit processors should be written primarily to test 32-bit operations. Applied to "The New Generation: High-Tech Horsepower" article, the Fibonacci test (listing 1) should generate the largest Fibonacci number that will fit in 32 bits (or one bigger than 16 bits). The Sieve of Eratosthenes (listing 3) should find all primes up to at least 100,000 and use a flag array well in excess of 64K bytes. The Quicksort test (listing 4) should sort at least 64,000 numbers.

These changes are important when benchmarking the 80386 because it performs differently in 16- and 32-bit modes; only with suitable benchmarks can we be sure that the results are representative of 32-bit applications.

The changes I have suggested are also important when comparing the 80286 and the 68000 with the 80386 and the 68020. Sixteen-bit processors (80286) will run the benchmark slowly or not at all, while 32-bit processors (68020, 80386, and 68000) will show their true performance.

About register variables: When benchmarking its processors, Motorola would like you to declare all character, integer, long, and pointer variables as register variables, since registers are a major feature of Motorola's architecture. In contrast, Intel would like you to avoid all register variables when benchmarking, because registers are *not* a major feature of Intel's architecture.

Rather than yield to either pressure group, I believe that you should perform the benchmarks both with and without register variables, publish the values, and let the readers decide whether they will use register variables in their application programs.

E. Stanbury
Lakemba, Australia

Applauding Ada

It is unfortunate that Joel West's book review of *The World of Programming Languages* (June) was filled with anti-Ada propaganda. Ada is a registered trademark of the U.S. Government (Ada Joint Program Office). Mr. West applauds Modula-2 for having extensible data types, yet he fails to mention that Ada does, too. He criticizes Ada for not having spawned another language. That is a strength, not a weakness. Ada is complete; substitutions are not needed.

Mr. West did say nice things about Pascal. But he failed to say that Ada is based on Pascal. He claims that Ada is a "huge language." Not true. It has only 63 reserved words. COBOL, the world's most popular language, has almost 500.

Mr. West was upset that C was not covered more thoroughly in the book. That is because C is nothing more than

continued

warmed-over PDP-11 assembly language. Ada was designed with these overriding concerns: efficiency, program reliability and maintenance, and programming as a human activity. I have used Ada for several years. I think that it is elegant, well-designed, and fun.

Mark Fowler
Huntington Beach, CA

Calculating Pi

John T. Godfrey's letter (May, page 20) describes a very clever algorithm for computing pi by means of calculating the perimeter of the inscribed/circumbscribed regular polygons of 2^n sides. While his version of this algorithm is very cleverly formulated, using *ratios* of successive circumferences as it does, the basic idea is, as he suspects, not new. In fact, it is due to the genius of Archimedes, who used it over 2000 years ago to obtain estimates of pi correct to three decimal places. This is doubly remarkable since the mathematics of Archimedes's time did not have the algebraic or decimal notation that we now enjoy.

One of the reasons this algorithm is not used very often is that it neither uses calculus nor is particularly fast in its convergence. Therefore, it is not taught in calculus courses, nor is it used in research-level pi calculations. Perhaps the most rapidly converging *series* for pi is the following, due to S. Ramanujan:

$$\frac{1}{\pi} = \frac{\sqrt{8}}{9801} \sum_{n=0}^{\infty} \frac{(4n)!}{(n!)^4} \frac{(1103+26390n)}{396^{4n}}$$

At the moment, the most rapidly convergent method of calculating pi is not by series, but by an iterative method using Gauss's arithmetic-geometric mean. The method is due to J. M. Borwein and P. B. Borwein (*SIAM Review* 26, 1984, pages 351–366, and *BIT* 26, 1986, pages 123–126). A nice discussion can also be found in *The College Mathematic Journal* (May 1987, pages 230–235).

Mark Bridger
Boston, MA

John T. Godfrey's letter on a formula for pi (May) is more accurate than the formula I derived, but it is based on the same principle. Mine may be easier to do on a hand calculator, however, because only one variable is used.

Starting with a 0, add 2 and take the square root. Keep adding 2 and taking the square root for the desired number of iterations, but on the last one subtract the number from 2. Multiply the result by 2 to the *n*th power, where *n* equals the number of iterations. On my Hewlett-Packard 11C, the answer for $n=8$ is within 0.0007 percent of the true value. For $n>8$, the answer is less accurate due to round-off error.

Frank J. Wilson
Mill Valley, CA

FIXES

Hidden Flaw

BIX now contains an article by Peter J. Becker called "Writing Interrupt Service Routines for the IBM PC in Turbo Pascal." It corrects one shortcoming in the article "Concurrent Programming in Turbo Pascal" by Mukkai S. Krishnamoorthy and Snorri Agnarsson (April). The techniques in the latter article are valid, but the implementation of an interrupt-driven tick counter in listing 8a (on page 133 of the April issue) has a hidden flaw: It crashes the IBM PC if you interrupt the main program with a Control-C. The BIX article shows how to correct this shortcoming and further explores the topic of running interrupt-service routines from Turbo Pascal. ■

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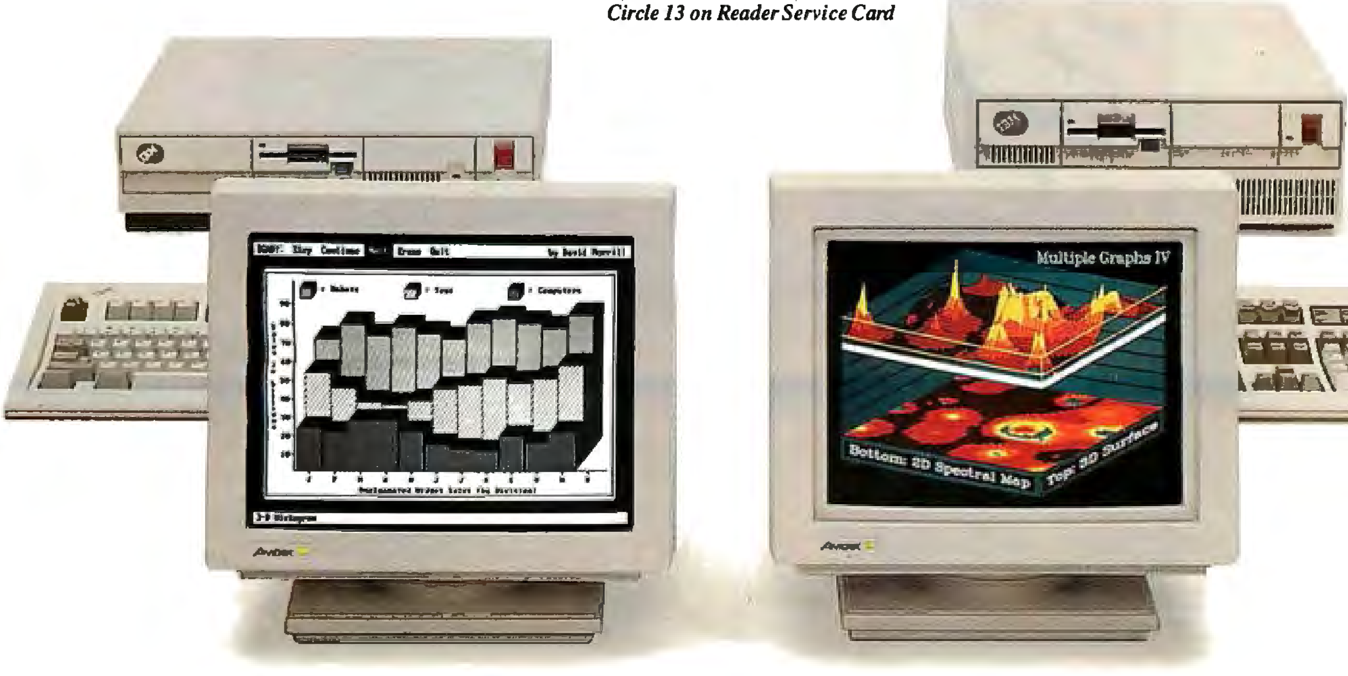

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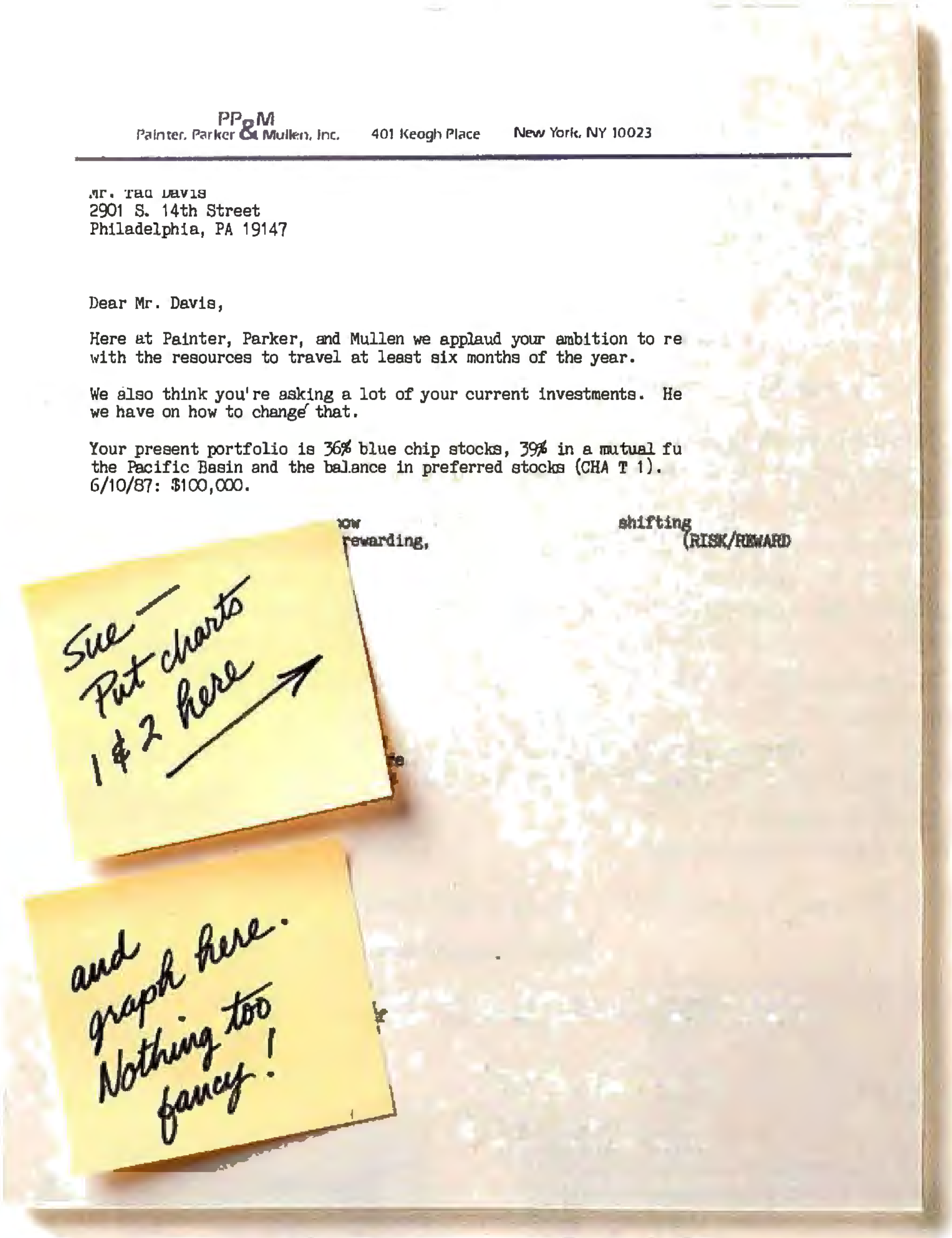

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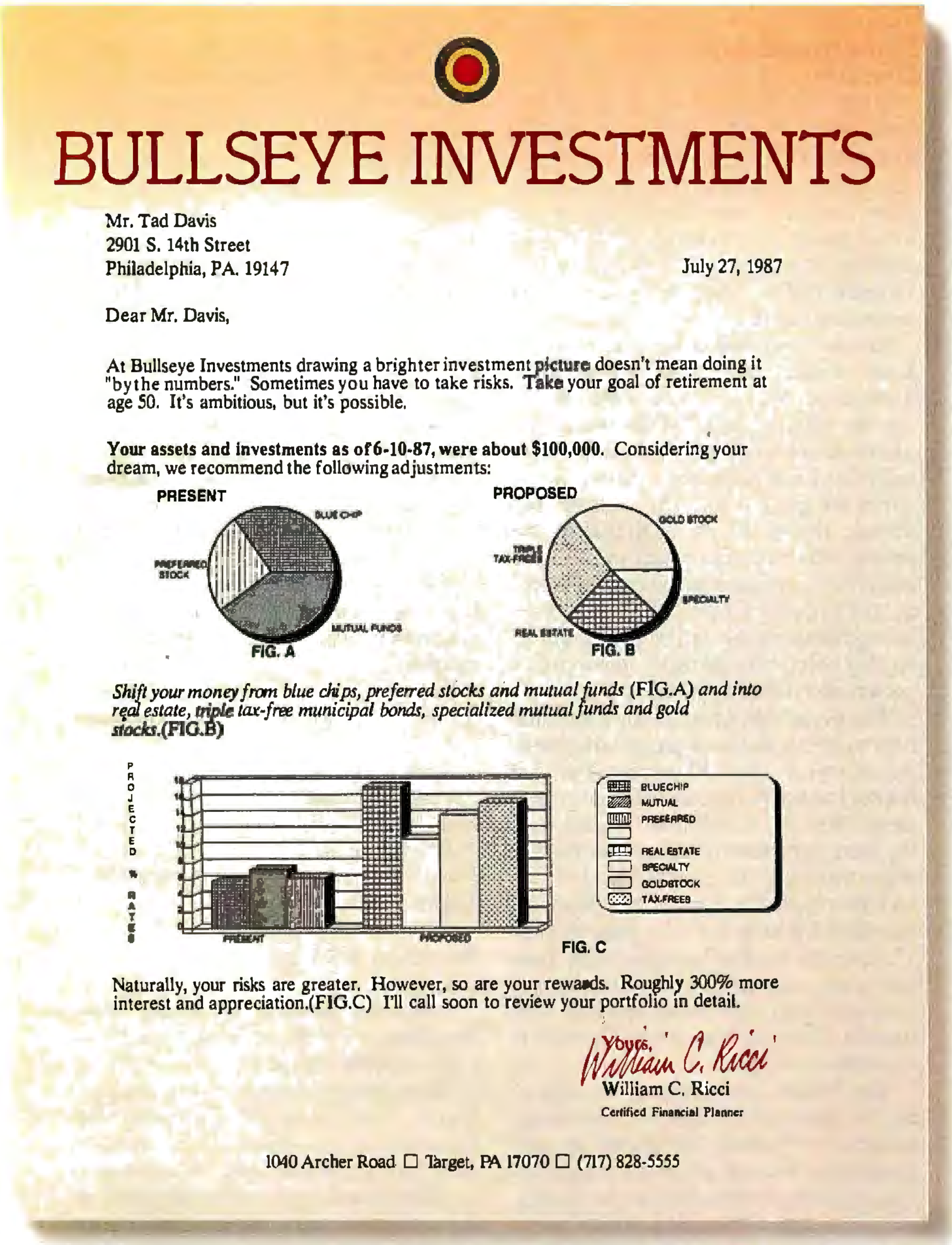
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CHAOS MANOR MAIL

Conducted by Jerry Pournelle

Letter from Europe

Dear Jerry,

Right now, I am trying to decide just how badly I want (or need) to access BIX and other U.S. public networks. Would you like to know how much the Bundespost charges for transatlantic data traffic? I could really eat up my paycheck if I get a modem (charges) and an account on the German Datex-P network (charges) and move data (more charges).

People need information in order to know enough to ask questions to get more knowledge. Vicious circle, right? Reading the "Best of BIX," I get tantalizing glimpses into what by now must be a considerable knowledge base. Having it just out of my grasp is really frustrating. But the question is still there. In reality, the people who run (and price) the systems are controlling who has access to them. Set the price for correct information high enough, and no one will be able to use it. At that point, who is really in control of society and public opinion?

The French program to put a terminal next to every phone is progressing well. At last report, about 50 percent of private homes had the devices installed and operating. Now the French have to deal with the next step: how to police the abusers while providing the expected level of service to responsible subscribers. Remember when CB radio got so popular so fast? The service became saturated with fools and idiots, so much that legitimate users gave up. Soon, just about everyone quit using it. Now, so I am told, CB radio is tolerable once again.

The French are seeing an analogy to this in their public network. The seamy underside of society has reared its ugly head in the form of obscene conferences ranging from simple requests for heterosexual liaisons to bestiality, kiddie porn, and neo-Fascism. As it should be, the nature of the network software ensures the relative anonymity of the user. Since there is no restriction on who can enter a conference, young children and the not-quite-sane have equal levels of access. The whole ugly specter of censorship and who is capable of judging the competence of another human being is involved.

I have no doubt that the French will be able to sort out an enlightened solution. But as conferencing systems grow in the United States, you are sure to experience many of the same problems. The difference in the United States is that some of the less tolerant groups will attach their vision of society to a religious (or political, or whatever) banner and do their best to shut down the systems that offend their sensibilities. Their fear of the future will force them to act so, rather than face the ultimately liberating and civilizing (we hope) influence that increased knowledge brings.

Working for a German firm, I am getting a good taste of the computer angst, or fear, that exists here. Not to beat this unpleasant issue to death, but the German people do know what national socialism could have done had today's computer technology existed in 1936. As a result, every database (public, private, or governmental) that is in machine-readable or -sortable form is subject to constant scrutiny. The holders of the database must continually justify the existence of the records.

Charles Kuhlman
Mannheim, West Germany

Thanks for the update on conditions in Europe. We think BIX is a bit overpriced here! You have my sympathies.

It will be interesting to follow the French experience with networking. Thanks again. —Jerry

WordStar 4.0 Flaw

Dear Jerry,

I recently received an update from WordStar 3.3 to WordStar 4.0 and found a very serious flaw in it.

When using WordStar 4.0 to generate source code for BASIC programs, the line-drawing functions Alt-F1 through Alt-F10 must not be used. Attempting to use such source code will totally lock up the computer, requiring the machine to be powered down to restore control. This is also true if the line graphics are generated using the Alt key plus a three-digit code. The computer will lock up when attempting to read the source code.

An examination of the code generated using the line-drawing graphics of WordStar 4.0 shows that the hexadecimal codes generated are different from those generated when using the line-drawing graphics codes of WordStar 2000 2.0. The graphics codes generated using

continued

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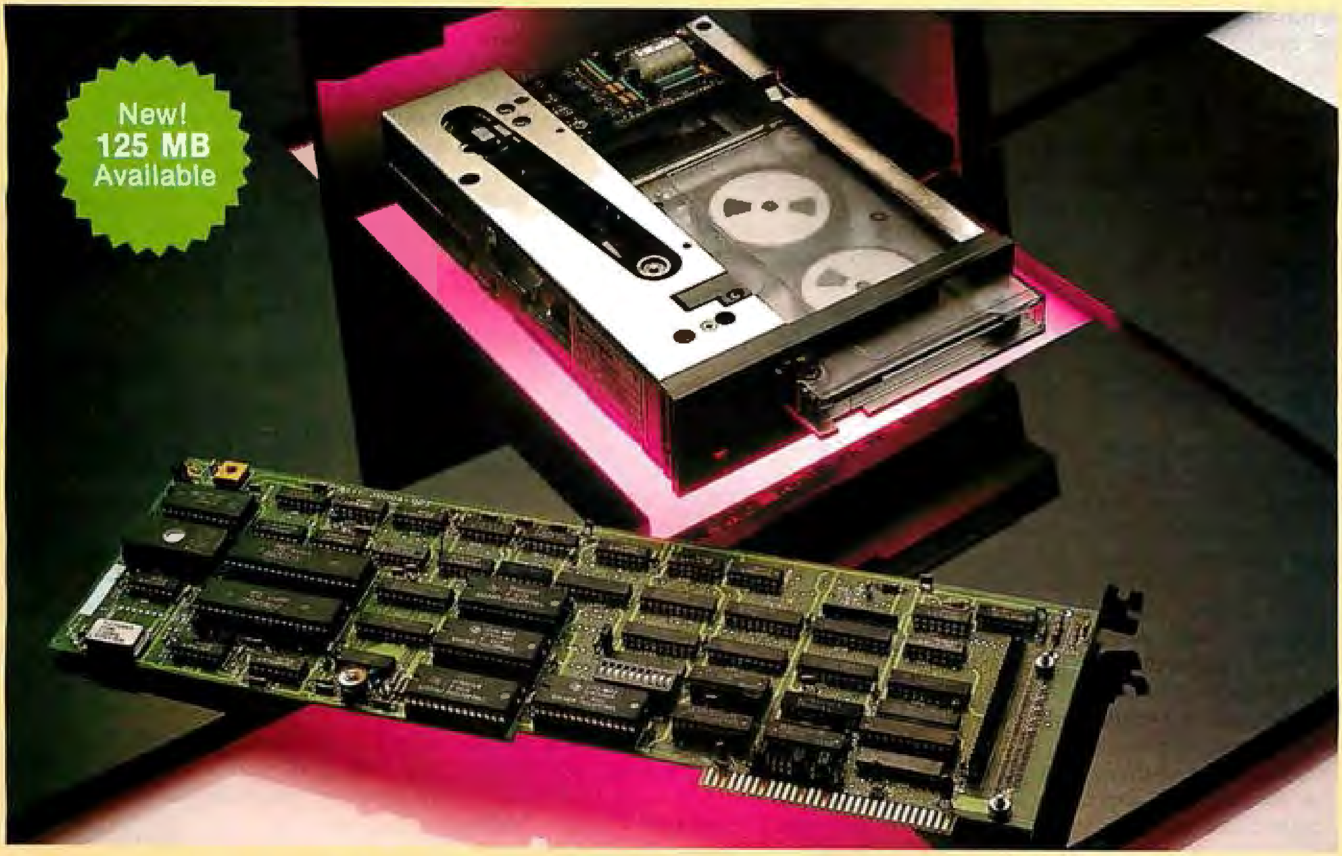

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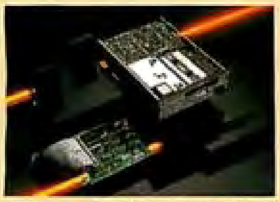

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WordStar 2000 work correctly with the BASIC language.

Thomas S. Cox
Greenville, SC

Thanks for the info. I confess I don't use WordStar as a programming editor; I prefer Brief or First Time.—Jerry

Praise for Pascal

Dear Jerry,

Your short remark about FTL Modula-2 in your February column made me think of my own experience with various programming languages. As a student in computer science (we call it "Informatik"), my first computer language was Wirth's Pascal. Maybe I'm a little short-sighted, but I think Pascal and its follower, Modula-2, are the best general-purpose programming languages. Thanks to Turbo Pascal, they're even suitable for quick-and-dirty little programs for one-time use. I have never learned BASIC, and I don't intend to. Seeing those silly line numbers and that ancient subroutine call scheme, I cannot understand why BASIC could survive.

Okay, current implementations give you very powerful functions, but it's all spaghetti because the concept of BASIC is spaghetti. Unfortunately, a great deal of serious (commercial) PC programming continues to be done in BASIC.

Manfred Jeusfeld
Aachen, West Germany

Well, BASICs are getting so many features that it's hard to tell some of them from Pascal except that BASIC has easier string-handling functions.

I agree, though, that if you have Turbo Pascal or FTL Modula-2, you don't need to learn BASIC in the first place.—Jerry

Stow the Nets

Dear Jerry,

I was appalled at your column in the April BYTE. Has what I've known and loved as personal computing gone the way of all silicon? Far be it from me to define what is or isn't personal computing, but I hardly think the vast majority of lowly mortal users can relate to the vast Olympian network you describe. I mean, you do get every piece of hard-/firm-/software under the *sun* for the asking, and it's great that you can link them all together, but other than yourself and a few very large corporations, who could possibly afford this?

Perhaps I've missed the bus. Most home users I know make do with one machine. If most companies are smart, it would seem to me that they ought to stick with one computer maker and go with its local area networks, terminals, or whatever—this would at least be simpler.

On the whole, I really like your column (and your science fiction), but I really think this sort of thing should be filed away under Possibly Productive Ergonomic Esoterica. Let's get back to helping The Rest of Us.

John J. Ross
New York, NY

The PC Arcnet isn't that expensive, and by using a PC or clone as the controller for a powerful system like the CompuPro, you can get quite a lot done. Agreed, it isn't for everyone, but surely we're still in the price range of microcomputers?

I agree, I have a great deal of equipment around here, and some of it is pretty advanced, but it has been my experience that today's expensive start-of-the-art equipment is tomorrow's required system; after that it becomes obsolete. A lot of people have been touting 1987 as the year of the LAN; surely I can be forgiven for experimenting with networks? After

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all, the motto is, "One user, at least one CPU . . ."—Jerry

Macintosh II Looks Good

Dear Jerry,

I just read a product preview of the new Macintosh II. My previous gripe with the Macintosh was its lack of color capability, expandability, MS-DOS compatibility, and its small screen size.

The color capability issue is, admittedly, a personal preference of mine. Expandability is necessary since personal computers still require modifications to the base unit to suit individual preferences. MS-DOS compatibility is necessary since we are reluctant to trash all our software for a new machine. As for the small screen size, I have the same gripe as you. A small screen is a crime on the eyes.

The new Mac II solves most of these problems, and in addition it adapts a useful bus architecture, the NuBus, and relegates most of the graphics and sound-thrashing to hardware, where it should be. The system looks to be the dream machine I have always wanted: a VAX-like microprocessor (68020), excellent color graphics, expandable architecture, and a good software base. Now, if the price were below $2000, I'd suck one up in a minute.

David Nakamoto
Pasadena, CA

We're in agreement on just about every point, especially on software investments forcing us to get DOS compatibility.

They tell me I'll get a Mac II Real Soon Now. I sure hope so; I've been impressed with all I've seen.—Jerry

Undocumented Feature

Dear Jerry,

After many phone contacts with AT&T regarding a problem I found with its version of MS-DOS, I received a letter explaining the source of difficulty and the proposed corrective action to be taken (if any/if needed/if ever). It reads:

> Thank you for reporting the inconsistency between the AT&T and IBM versions of MS-DOS, in dealing with interrupts while in a batch script. The inconsistency is due to an undocumented feature of the IBM version, and could therefore be changed by IBM at any time. Therefore, before any changes are made, if any changes are made, the problem will have to undergo further review. If a change is made, it will be included in a future release of MS-DOS.

Jim Sorrells
Somerdale, NJ

Yeah. Wow. Thanks for showing it to me.—Jerry

Not-So-New Keyboards

Dear Jerry,

Regarding your comments in the April BYTE on the "new" keyboards for IBM PCs and clones, let's give credit where credit is due. DEC Rainbow owners have been noting with irony that these keyboards look suspiciously like the LK201 keyboards that came with their computers.

Now that DEC is backing out of the microcomputer business, maybe we'll start to see other "advanced" features, such as true scrolling, crop up on other machines.

Carl D. Neiburger
San Jose, CA

DEC tried as hard as it could to alienate the micro community, and lo! it succeeded nicely.—Jerry ■

 Circle 69 on Reader Service Card

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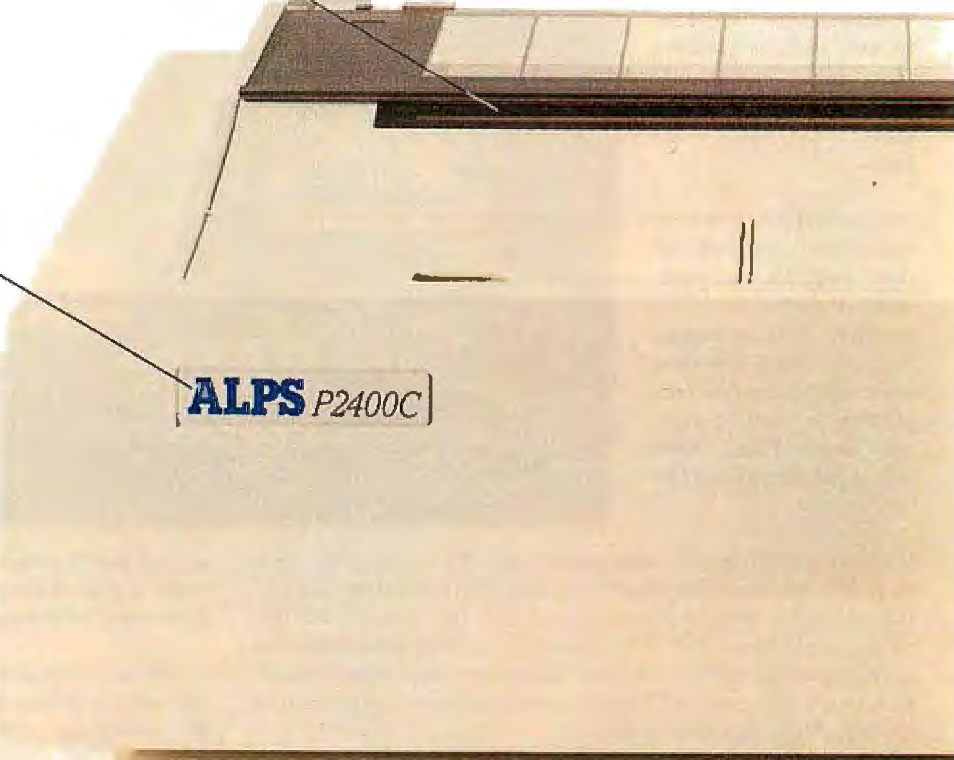

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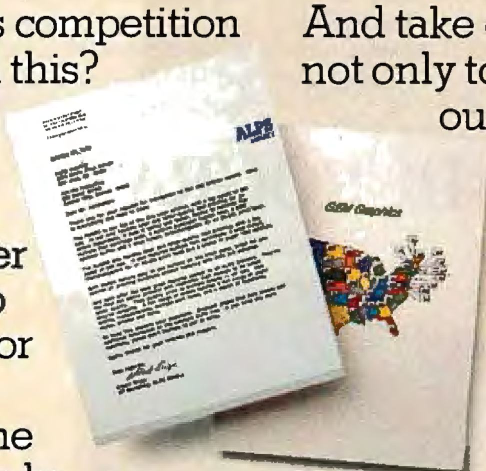

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Circle 11 on Reader Service Card (Dealers: 12)

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

Optical Storage Growing Up, Facing the Magnetic Challenge

No one ever said making an optical disk was easy, certainly not manufacturing experts at a recent conference on optical drives and media. As Richard Zeck, of Rothchild Consultants (San Francisco), explained, you have to worry about things like the multiple layers of a disk matching both optically and thermally and tracks only 1 micron wide, 10 to 15 times narrower than with magnetic media.

Richard Gardner of 3M Company (Vadnais Heights, MN), a major North American producer of optical disks, described 3M's manufacturing process as having more than 1000 separate steps per disk, 475 of those steps in the thin-film deposition process alone. The most critical factor, at least from 3M's perspective, is the implementation of on-line diagnostic devices that measure key observable parameters, such as bonding and lamination and handling. "Testing must occur inside the system as the product is being made," he said. "The only thing you learn from downstream testing is that what you just made is garbage."

According to Gardner, the 3M optical disk manufacturing line is monitored by a single person, the control operator, who watches each step of the process for each disk. With each step, data is sent back to the operator, who then analyzes that data using a mainframe computer. Modifications can then be made during the manufacturing process. "We know while a disk is being made whether or not it is any good," Gardner explained.

Frans Carpay, director of manufacturing for Philips and DuPont Optical Company (Nieuwegein, The Netherlands), explained that it now takes 7 minutes to make a disk ("In one end of the line, you put in granulate; at the other end is a disk") and that overall production yield is 25 percent greater than with first-generation techniques. Carpay stated that the company currently produces blank disks that can be sold to customers for between $1.60 and $1.70 each.

Even though the optical storage industry is still in its infancy, said Zeck, it's mired in a period of transition. "There will be at least three, maybe five, generations of products," he said, "and we are only in the first generation." Zeck said that by the 1990s, "Optical storage will be a very large successful market."

Zeck described several trends he sees developing in optical memory, particularly the emergence of 5¼-inch, half-height drives. "There's no question about it," he said. "A majority of the optical drive manufacturers will be making 5¼- and before long 3½-inch units that are half-height because this is what the market wants."

Developments like holographic optical elements, higher power laser diodes (which use shorter wavelengths and diode arrays), better position sensors, and single-element molded aspheric lenses have enabled manufacturers to design smaller drives that have multiple heads, Zeck said. He explained that innovations like diode lasers with shorter wavelengths will make doubling of the bit and track densities possible, effectively quadrupling the storage capacity, while laser diode arrays will permit multichannel read/writes. Some of the laser diode arrays may also incorporate fiber-optic arrays.

Zeck predicted such innovations will gain widespread use in the next three years; we'll also see optical drives with 30-ms access times, he said.

Zeck doesn't discount magnetic storage altogether, however. He sees the "continuing evolution of magnetic technology, which annually improves in both capacity and throughput and decreases in price" as one of the most formidable challenges optical storage must overcome. In many environments, magnetic storage is still more cost-effective than optical storage, and systems like Konica's high-capacity 5¼-inch disk drive continue to make it tough on optical devices. In addition to high costs and sometimes low performance, Zeck said, the biggest problem for optical storage is both the lack of stan-

continued

Nanobytes

Amid all the glittering graphics technology at SIGGRAPH-87, we found a humble new device for controlling screen images. Called the **Spaceball**, this tangerine-size unit, mounted to a molded base, is filled with force/motion sensors; when you twist the ball, the sensors read the direction of the pressure and rotate the image on the screen accordingly. Push on the ball and the image recedes into the background; pull it and the image moves into the foreground. The pickups are filtered to eliminate the first 10 percent of motion. Inventor John Hilton said that because the Spaceball has its own processor, it can be software-configured to work with any system or application. Spatial Systems (Milsons Point, Australia) is testing the device now; at press time, it wasn't yet being marketed. . . . **The Software Link** (Atlanta) sounds pretty sure of its PC-MOS/386 operating system for 80386-based machines. The company says that if a commercial application or utility doesn't run under its OS, it will work with the developer to fix the cause of incompatibility. If they can't correct the problem, the owner can return PC-MOS/386 and get a full refund. . . . **Mercury Computer Systems** (Lowell, MA) showed at SIGGRAPH an add-in board for IBM PC ATs engaged in computation-intensive work. The MC3200 Micro-Supercomputer, built around the Weitek 8032 chip set, uses three 32-bit processors to handle program sequencing, integer processing, and floating-point operations. Mercury claims performance of 5 to 25 times that of an 80386/80287 combo. With 2 megabytes of RAM, the board costs $8000; the software de-

continued

velopment package is $8500. . . . **The Semiconductor Industry Association** (Cupertino, CA) has appointed five scientists to an advisory panel that will study the possibility of doing a study on possible health hazards of working in a chip fabrication plant. The head of the panel said it will first try to find researchers interested in doing an epidemiologic study of workers at semiconductor plants. . . . **MIT's Randall Davis** told a group of manufacturing planners that **factory automation** won't save much money on the assembly line but will have an impact at the inventory level, where there's more room for cutting costs (he said that only 5 percent to 10 percent of a factory's resources are devoted to assembly). Davis speculated that robots and expert systems may have their biggest impact on middle managers. "Maybe the real consequence of factory automation will be in thinning management ranks, since these are the people who have typically dealt with inventory and accounting, areas that will need less management in the future." . . . **TokiAmerica Technologies** (Irvine, CA) will soon start shipping its wire, which contracts, just like muscle tissue, when current is applied to it. Called BioMetal, it's a nickel-titanium member of the shape-memory family of alloys. According to a company executive, one disk drive maker is exploring BioMetal's use as a replacement for the solenoids and small electric motors that raise and lower the drive's read/write heads. The metal doesn't emit a large magnetic field. Another researcher reportedly has used the wire in a robot arm to probe integrated circuits. . . . **Data Technology** (Santa Clara, CA) says it will come out with a smaller, less expensive model of its CrystalPrint VIII, a page printer that uses a liquid-crystal shutter. The CrystalPrint IX will print six pages per minute and will be priced "at the bottom of the market."

dards and the lack of an industry leader. "The very diversity of optical storage options is perhaps its biggest negative," he said. "IBM's announcement of its 3363 [optical drive in April] was very important, but we're still waiting for the overall breakout type of leadership that's needed."

The Minicomputer: An Endangered Species?

"Taking aim" might be the best way to describe the combined Microsoft/Intel position regarding the future of 80386-based personal computers running the Xenix operating system. Both Steve Ballmer, vice president of system software at Microsoft (Redmond, WA), and Claude Leglise, 86-family marketing manager at Intel (Santa Clara, CA), described an 80386-based Xenix system as having power that not only rivals a DEC VAX, IBM 370, or Hewlett-Packard minicomputer but that outperforms those systems.

"The top three contenders in the minicomputer market," said Leglise, are the IBM 370, DEC VAXes, and an 80386-based IBM PC. "All offer 32-bit capabilities, a large address space, and virtual storage architecture. However, a '386 today delivers more CPU power than the IBM or VAX." Ballmer agreed, stating "386 Xenix is a multiuser system that competes with low-end VAX, an IBM System 36, and a Hewlett-Packard minicomputer more so than it competes with DOS." According to Ballmer, the installed base of Unix/Xenix users exceeds 250,000, making it the largest installed base for multiuser operating systems in the world. "Some people don't think 250,000 is a very big number," Ballmer said, "and it isn't if you compare it to 10 million DOS users. However, it is a very big number if you compare it to the fewer-than-100,000 VAX VMS installed base."

Both men lauded the standardized, binary Unix platform the 80386 makes possible. "No other processor or architecture can make this claim," boasted Leglise, while Ballmer added that "it's a way of putting a level of standardization into the minicomputer market."

According to Ballmer, Microsoft's operating system strategy is threefold: DOS and Windows for real mode, OS/2 for protected mode, and Xenix for multiuser environments. "DOS and OS/2 remain single-user systems," said Ballmer. "We will use OS/2 to penetrate mission-critical markets like airline reservation systems."

Paul Sribhibhadh, Microsoft's Xenix marketing manager, told Microbytes Daily that Xenix sales "are doing better than ever since the OS/2 announcement." Ballmer said Microsoft has "never had a higher level of Xenix development" than it does now. According to Sribhibhadh, the Xenix development team at Microsoft consists of about 30 people.

Leglise, who noted that the 80486 won't be available for quite a while, predicted that by the end of the century, Intel "will deliver a chip that will compete effectively against a mainframe."

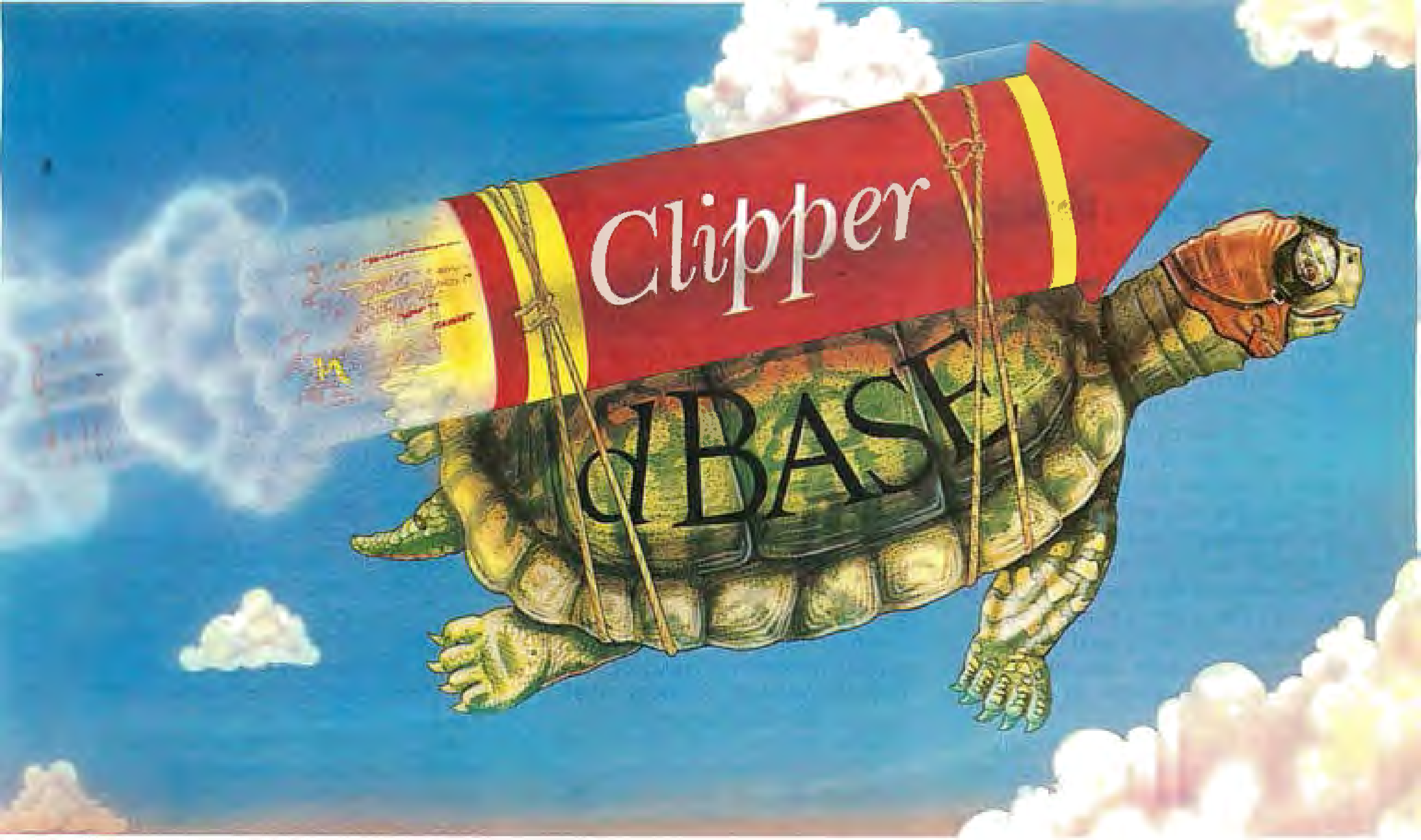
Coprocessor Will Enhance Amiga Graphics

A prototype parallel imaging coprocessor board has been developed for the Commodore Amiga 2000 by the University of Lowell (MA) Center for Productivity Enhancement. Called the Amiga Parallel Imaging Coprocessor, the card is built around the NEC μPD7281 Image Pipelined Processor (ImPP), which executes at the rate of 5 million instructions per second. However, because the board can accommodate as many as seven ImPPs, an effective processing rate of up to 35 MIPS can be achieved. The board can also perform DMA transfers of images within 512K bytes of graphics memory and within up to 8 megabytes of system memory.

According to Georges Grinstein, associate professor of computer science at the University of Lowell, the board is programmable and will come with a development environment that includes an ImPP assembler, a run-time support library, and an image-processing library (filters, geometrical operations, processing routines, and so on). The board can be programmed through the C run-time library or through an imaging kernel system (also developed by the University of Lowell).

Grinstein said at SIGGRAPH-87 (in July) that the board would soon go into production and would be available in September for approximately $2000.

continued



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Some Researchers Concerned with Defense Funding of AI Projects

One of the most heated topics of talk at the recent AAAI-87 in Seattle concerned the role of the Department of Defense's Strategic Computing Initiative (SCI) in AI research. AI researchers, particularly those in universities who see themselves as "antimilitary," are facing a real dilemma: They don't want their work used for military applications, but no one else seems ready to pay the bills. The only realistic perspective, according to Rod Brooks, an MIT researcher heavily involved in the SCI-sponsored Autonomous Land Vehicle (ALV) program, is to realize that research results can be used for all sorts of purposes and that a researcher cannot assume responsibility for every eventual application.

Randall Davis, another university researcher working on SCI-related projects, agreed, pointing out that many of the algorithms being used with missile systems were originally developed by medical researchers. Jon Jacky of the University of Washington concurred: "You can never have complete control over the results of your work."

SCI, with its 1987 budget of slightly more than $116 million, is a DARPA (Defense Advanced Research Projects Agency) program started by Robert Kahn in 1983. SCI has four major goals: to advance machine intelligence technology, to aid in the transition of this technology from laboratories to industry, to increase the availability of trained scientists and engineers, and to provide a broad base of supporting research for advanced machine-intelligence technology. General areas of technology research include computer vision, speech processing, natural-language processing, knowledge-based systems, integrated interfaces, architectures, and microelectronics.

More than one-third of SCI's 1986 $116.3 million budget was released to university research laboratories; 26 percent was allocated for multiprocessor system architectures, 20 percent for applications (e.g., ALV), and 16 percent for machine intelligence. Although the 1987 budget will be cut to just over $104 million, the 1988 projected budget will be up to about $120 million. Robert Simpson, the DARPA administrator responsible for overseeing SCI, added that SCI is the funding source for AI and computers within DARPA.

Questioned about the relationship between SCI and the Strategic Defense Initiative (SDI), commonly referred to as the "star wars defense," Simpson pointed out that the two are not related; however, "technologies developed by SCI are available to the entire Defense Department." Simpson mentioned that SDI researchers are very interested in the parallel computing architectures at Carnegie-Mellon University (see the story on the Warp Computer in April's Microbytes, page 10).

When asked why SCI funds could not be turned over to a nonmilitary agency, such as the National Science Foundation, for distribution to universities, Simpson said "it's unlikely" that the DoD would agree to deliver millions of dollars to the NSF simply to create the impression of "clean money."

No LAN Is an Island, E-Mail Panel Says

The lack of intersystem connections has been the single biggest obstacle for electronic-mail users and vendors, according to a panel of e-mail experts speaking in San Francisco recently.

But one panelist, Richard Miller of Telematica (Palo Alto, CA), said the technical problems of "interconnecting islands of communication" have been solved so that users of one e-mail system can send and receive mail to and from users on other systems. The problems that now exist, said Miller, are primarily administrative.

"Within companies, the problem is to convince the various parts of the organization that they really can talk to one another," said Miller. "Usually that isn't dealt with until a CEO finds out he can't send a message to the entire company." Peter Westwood, vice president of Sydney Development Corp. (Vancouver, British Columbia), added that more than 80 percent of the e-mail systems that serve the more than 6 million active e-mail users in the United States are capable of communicating with one another, but whether or not they actually do is another matter.

Miller and the other speakers on the panel credited the adoption by e-mail vendors of the X.400 protocol standards with helping greatly to make interconnection possible. Those standards are backed by the Electronic Mail Association and are now being considered for adoption by the National Bureau of Standards in the United States and by Cen/Cenelec in Europe.

"We are at the point today," Miller said, "where X.400 is no longer a dream. Real services and real products are out there." X.400 is a global messaging interconnection protocol that defines the envelopes and text format of message naming, addressing, and routing schemes.

When asked about the implications that X.400 might pose for broad-based Unix systems like Arpanet, UUCP, and others, however, Westwood admitted it is unlikely that those systems will adopt the X.400 protocol. Instead, vendors, like Westwood's company, will be offering gateways to those systems.

Russell Briggs, an e-mail consultant and president of DA Systems (Campbell, CA), agreed. "The Unix systems work now," said Briggs, "and there probably will be little incentive to adopt X.400. The alternative is to provide gateways." Briggs added that implementing X.400 protocol is not cheap and predicted that many e-mail systems will turn to gateways or to services like DA System's recently introduced DASnet.

DASnet is a service that allows the exchange of electronic mail between users of most of the major e-mail systems. With a DASnet, an e-mail user can reach almost everyone who has an account on a public or for-fee system using the mail system with which they have become familiar, regardless of the destination.

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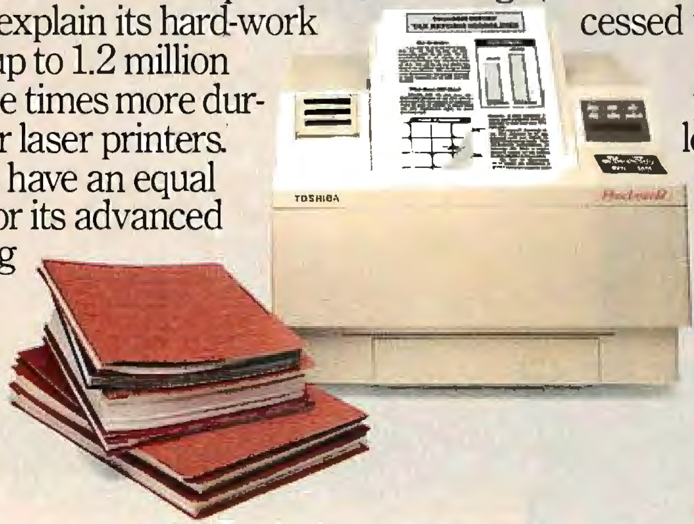

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Circle 206 on Reader Service Card

Fortune's Supermicro Supports 2 to 20 Users

Sporting a 68020 processor running at 16.5 megahertz, the Fortune Formula 4000 is a desktop computer system that supports from 2 to 20. The system runs Fortune's proprietary Unix-based operating system, FOR:PRO. The company says system V.3 will be released later this year. Also available is Fortune:Works, a package that lets IBM PCs and compatibles access FOR:PRO files.

The 4000 includes four standard expansion slots, one of which is reserved for the SCSI host adapter. Two slots are also available for memory expansion. The main system has two full-height drive slots. An expansion cabinet with two additional full-height drives is also available.

Fortune's entry-level configuration includes 1 megabyte of RAM and a 40-megabyte hard disk drive. A fully loaded high-end system includes a 145-megabyte hard disk drive, 4 megabytes of RAM, a 60-megabyte tape-backup unit, and a complete set of Fortune Office Automation software.

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Page-layout functions include rotate, size, cut, and copy, and you can enter text into the page or cut and paste it in. Word-processing functions are also available.

A referencing function dynamically links all references throughout a document.

Interleaf reports that document length is limited primarily by disk size.

The program requires a Mac II. A color screen is recommended for use with WYSIWYG (what you see is what you get) features but is not necessary to run the program.

Price: $2495.

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Inquiry 576.

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If you want us to consider your product for publication, send us full information about it, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Information contained in these items is based on manufacturers' written statements and/or telephone interviews with BYTE reporters. BYTE does not represent itself has having formally reviewed each product mentioned.

Three Neural-Network Programs

MacBrain, a Macintosh neural-network-simulation program from Neuronics, supports up to 200 processing nodes and provides up to 40,000 connections. It contains an interpreter and paradigm shells. You can simulate adaptive resonance, the Delta rule, Boltzman machines, and Hopfield nets.

The program supports color on the Mac II and provides seven instruments to display units and four ways to display weights and links.

MacBrain runs on the Mac Plus, SE, or II. The company plans to support Transputer-based boards in a future release that will also include two programming languages.

Price: $99.

Contact: Neuronics Inc., P.O. Box 738, Cambridge, MA 02142, (617) 367-9254.

Inquiry 577.

NeuralWorks is an IBM PC development tool for designing and building neural applications and models. It uses a graphic intuitive interface and offers editing, execution, tuning, and observation capabilities. The editing functions let you lay out the network in layers, then interconnect the layers with one of four methods. You can specify the layers manually, replicate an existing pattern, connect them randomly with a specified density, or specify them fully connected. You can also modify the layers at any time without redefining the entire network.

The learning rule at each layer is programmable. Inputs include raster scan files and ASCII files. The program offers scatter diagrams of

continued

training inputs and outputs.

A maximum of 4000 processing elements with a total of 16,000 connections are provided. On an IBM PC AT with an 80287 math coprocessor, a maximum of 32,000 connections per second can be made.

NeuralWare also sells Solution Packs, a tutorial tool that lets you examine Rosenblatt's classic Perceptron neural model and Hopfield's Cross-Bar Associative Network.

NeuralWorks runs on IBM PCs or compatibles with at least 512K bytes of RAM and a graphics monitor.
Price: $99; Solution Packs, $49.
Contact: NeuralWare Inc., 103 Buckskin Court, Sewickley, PA 15143, (412) 741-7699.
Inquiry 578.

NetWurkz for the IBM PC is a neural-network tutorial. It models associative memory to find the nearest match to your input word. The emulator is limited to about 1000 neurons. The program comes with a PL/D compiler (NetWurkz is embedded within the PL/D language as data statements). The program also comes with source code.

To run NetWurkz, you need an IBM PC, XT, AT, or compatible with at least 256K bytes of RAM.
Price: $79.95.
Contact: DAIR Computer Systems, 3440 Kenneth Dr., Palo Alto, CA 94303, (415) 494-7081.
Inquiry 579.

Turn Your AT into a Neurocomputer

The Anza coprocessor board from Hecht-Nielsen Neurocomputer Corp. transforms any IBM PC AT or compatible into a neurocomputer that's capable of implementing a neural network. The Anza uses a 68020 processor and a 68881 floating-point coprocessor, along with 4 megabytes of one-wait-state RAM.

The system can implement neural networks containing up to 30,000 processing elements (neurons) with up to 480,000 interconnects. It can update the interconnects at 25,000 interconnects per second during learning and at 45,000 interconnects per second in feed-forward mode.

Software supplied with the Anza includes the User Interface Subroutine Library (UISL) and five Basic Netware Packages. The UISL is a collection of instructions that provide access to all Anza functions from within programs written in C, Pascal, FORTRAN, and BASIC. Each of the five Basic Netware Packages is a generic, user-configurable implementation of a basic network paradigm specifying the interconnection structure of the network and the form of the differential equations that determine the behavior of the individual processing elements. You can customize the Netware Packages to fit specific applications by modifying the number of neurons, their initial state and weight values, learning rates, and time constants.

The Anza is available both as a board/software package alone or bundled with a 10-MHz Zenith Z-248 AT-compatible with a 20- or 40-megabyte hard disk drive, an EGA board, and a monitor. In addition, the company offers three different training courses on working with neural networks.
Price: Board alone, $9500; with Z-248 and 20-megabyte hard disk drive, $14,950; with Z-248 and 40-megabyte hard disk drive, $18,950.
Contact: Hecht-Nielsen Neurocomputer Corp., 5893 Oberlin Dr., San Diego, CA 92121, (619) 546-8877.
Inquiry 581.

The VAXstation 2000 displays 1024- by 864-pixel color.

Low-Cost Color VAX

Digital Equipment Corp.'s VAXstation 2000 is a four-plane workstation (i.e., it has 16 simultaneous colors) with graphics resolution of 1024 by 864 pixels. The system's processor is the MicroVAX II chip set, and its proprietary graphics chip set is the same one used in the VAXstation II/GPX.

Two versions are available. The entry-level system includes the MicroVAX II chip set running at 20 MHz with a floating-point unit, 4 megabytes of RAM, a built-in Ethernet adapter, three-button mouse, keyboard, 15-inch color monitor, and software. A 42-megabyte hard disk driver is also available.

The advanced system includes a 19-inch color monitor. All systems include one-year on-site warranty service.
Price: Entry-level version, $4600; with 19-inch monitor, $5400; with hard disk drive, $10,950.
Contact: Digital Equipment Corp., The Mill, Maynard, MA 01754-2571, (617) 897-5111.
Inquiry 580.

A Disk Named Patrick Henry

Patriotic themes abound in a company named 1776 Inc. Case in point: Patrick Henry, a high-capacity hard disk–caching system with an average access time that the company claims is between 0.5 and 7 milliseconds, depending on system configuration. Tuning software included with the system lets you increase its performance by adjusting the cache to the application you're using; it guarantees that critical files will always be found in the cache when needed.

The system uses SCSI for connecting to the host and ESDI (enhanced small device interface) for intercommunicating among drives within a multidrive system. Data is transferred to the host at 1.2 megabytes per second. A 68000 processor provides intelligence for the system. Patrick Henry is compatible with MS-DOS, Novell Advanced Netware, and MS-DOS networks. The company has plans for Unix and Xenix compatibility in the near future.

Patrick Henry's built-in fault tolerance automatically reallocates disk space when bad sectors are suspected. It also keeps duplicate copies of the directories and file-allocation tables. The system's security features let you divide the disk into up to 256 password-protected sections.

Systems are available in capacities ranging from 70 megabytes to 1280 megabytes, with cache sizes from 512K bytes to 16.5 megabytes. Tape backup is available in 60- and 120-megabyte sizes.
Price: $9900 to $64,700.
Contact: 1776 Inc., 4522 Murietta Ave., Suite 700, Sherman Oaks, CA 91423, (818) 789-2004.
Inquiry 582.

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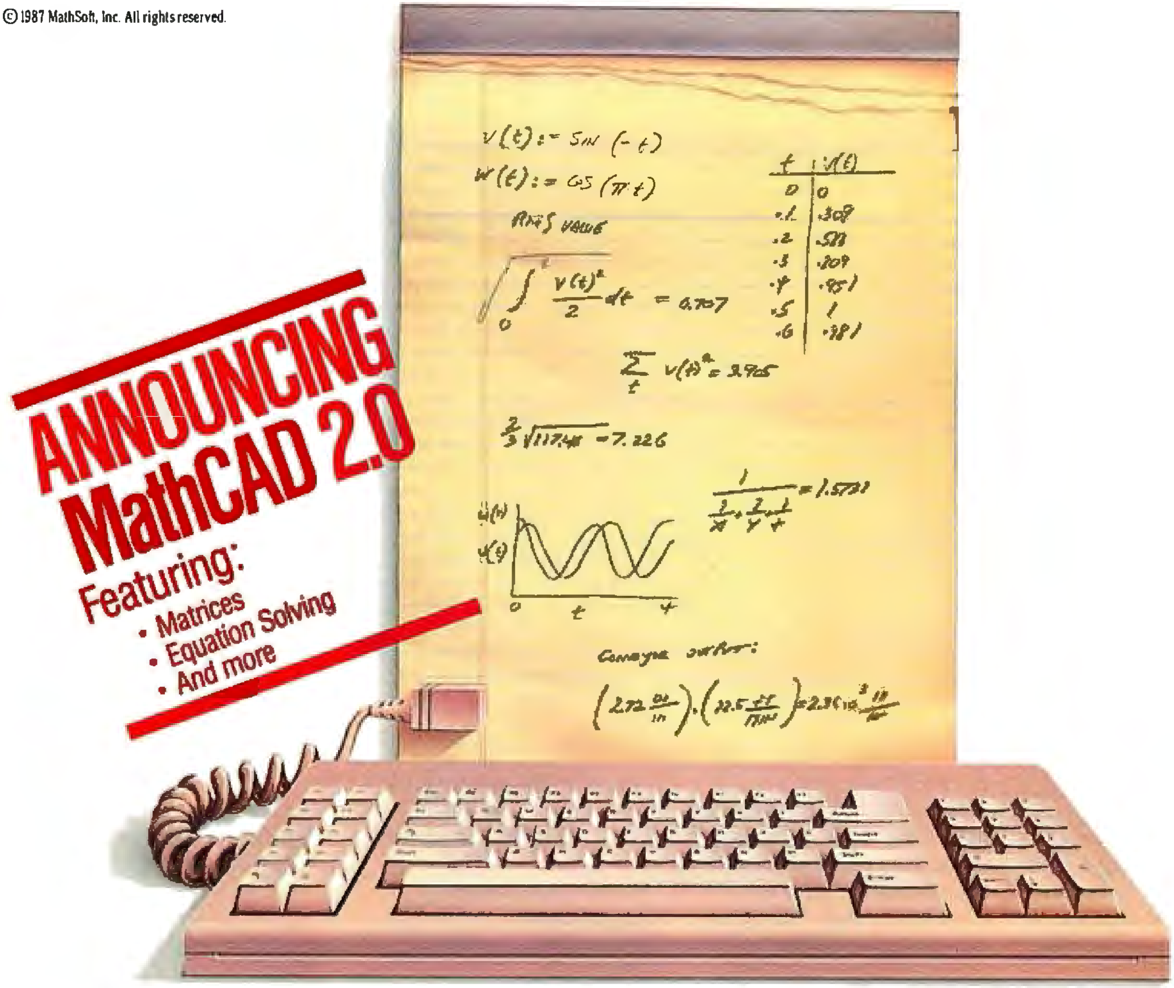

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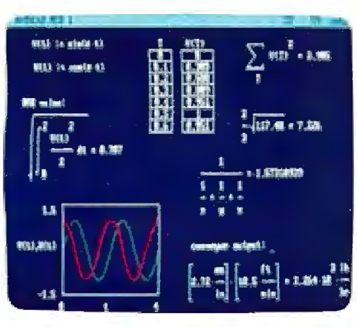

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NEC Upgrades Laptop Screen

The NEC MultiSpeed EL is an upgraded version of the NEC MultiSpeed laptop computer. As its name implies, it now has an electroluminescent, backlit, supertwist LCD screen. The screen provides you with a full 80 characters by 25 lines with an aspect ratio of 1.6 to 1 and a resolution of 640 by 200 pixels.

Also new on the MultiSpeed EL are brightness and contrast controls on the screen panel, a friction lock that holds the screen at the angle you choose, on/off switching of LCD backlighting, and automatic screen power-off. NEC claims a battery life of 4 hours.

If you own an original NEC MultiSpeed, you can upgrade your system to the new screen. Some early serial numbers have to be returned to the factory for upgrade. The rest can be upgraded either by the owner or by your local dealer.

Price: $2500; screen upgrade, $499.
Contact: NEC Home Electronics, 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
Inquiry 583.

NEC adds an electroluminescent screen to the MultiSpeed.

Artificial Intelligence Applied to Statistical Forecasting

Forecast Pro is an expert-system time-series forecasting program from Business Forecast Systems, the company that released Forecast Master. BFS reports that with Forecast Pro, prior knowledge of statistics is not necessary.

Artificial intelligence is used to guide you through a series of steps, or modules, that make up the forecasting process. Techniques include exponential smoothing, Box-Jenkins, and dynamic regression. The expert-system analysis feature performs statistical tests on the data and determines the characteristics and the power of potential explanatory variables or leading indicators. The system then describes the data statistically, recommends an appropriate method, and explains its reasoning.

Once you've chosen the forecasting procedure, automatic fitting options let you choose and optimize the model parameters. The program presents and interprets fitting diagnostics and can suggest a route to improve the model. You can also make your own decision at any time.

A set of diagnostic screens helps you compare different models. Other features include a full-screen time-series editor, graphics, user-defined variables, color capability, and batch-processing capability. The graphics facility lets you compare several forecasts and time series on the same plot with scaling options. You can output them to a variety of graphics devices or save them for interactive editing.

BFS is directing the program toward academic use as much as general business applications.

Forecast Pro runs on IBM PCs, XTs, ATs, and compatibles with at least 512K bytes of RAM and two disk drives. It also runs on the IBM PS/2 series and supports VGA graphics. An Intel math coprocessor chip is recommended.

Price: $495; academic price, $195.
Contact: Business Forecast Systems Inc., 55 Wheeler St., Cambridge, MA 02138, (617) 354-3745.
Inquiry 584.

Low-Cost PC-Based Telephone Management

BigmOuth from Talking Technology is a digital recording and telephone management system for IBM PCs and compatibles. It consists of a half-length card, software, telephone cables, and an external speaker.

BigmOuth's features include basic answering-machine capabilities and personal messaging, which gives users private mail boxes. The system can store up to 1000 messages, and you can retrieve them either locally or remotely from any Touch-tone telephone. The unit can also forward messages to other telephones and deliver messages at a prearranged time.

Software that comes with BigmOuth includes an autodialer with a database and an automatic activity log. All messages and hang-ups are stamped with the time, date, and a description of the activity.

To use BigmOuth, you need 256K bytes of RAM and at least two floppy disk drives, although a hard disk drive is recommended. Talking Technology also offers a licensing program for developers who want to integrate BigmOuth's voice features into their software.

Price: $239.
Contact: Talking Technology Inc., 6558 Lucas Ave. #301, Oakland, CA 94611, (415) 339-8255.
Inquiry 585.

Updated Dot-Matrix/ Daisy-Wheel Combo

Brother International's latest incarnation of its Twinriter—the Twinriter 6—combines faster dot-matrix and daisy-wheel printheads side by side in the same printer. The unit's daisy-wheel element prints at 36 characters per second, while the dot-matrix part of the system prints at 200 cps. The twin heads allow true letter-quality text and graphics to be mixed on the same page.

The Twinriter 6 prints up to 36 columns bidirectionally and supports the IBM extended character set in both letter-quality and draft modes. Options include a forms tractor, a single-bin sheet feeder, and a triple-bin sheet/envelope feeder. A parallel Centronics interface is standard, and an RS-232C serial interface is available.

Price: $1395; forms tractor, $169; single-bin sheet feeder, $325; triple-bin sheet feeder, $599.
Contact: Brother International Corp., 8 Corporate Place, Piscataway, NJ 08854, (201) 981-0300.
Inquiry 586.

continued

AI Development Environment

KnowledgePro, an artificial intelligence programming environment, includes hypertext capabilities, rules, and a list-processing language. Its hypertext capabilities enable you to present information in nonlinear form. You can display a screen of text with certain words or phrases highlighted, and the reader can follow that train of thought to other screens, which may also have highlighted phrases. You can also program any set of instructions (i.e., rules) or areas of the knowledge base to be activated when the reader selects specified concepts.

A "topic" organizes information into conceptual units containing a hierarchical structure. Each predefined command acts like a built-in topic, and each topic you write behaves like a system command. Topics include name, contents, descriptions, and machinery; and each can behave like a frame, object, function, command, or variable.

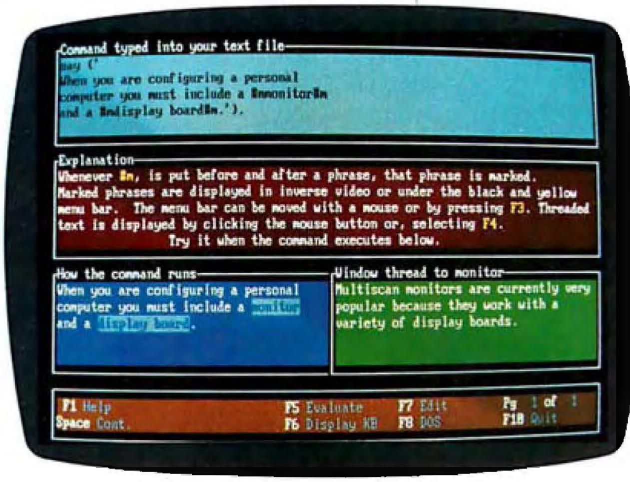
KnowledgePro lets you use rules and commands to manipulate words or word lists, change window colors, perform calculations, and access external files.

The program includes macro capabilities, a built-in text editor, mouse support, and sample knowledge bases.

Knowledge Garden used its KnowledgePro environment to create KnowledgeMaker, an induction program. It can extract IF... THEN rules from raw data and convert the rules into Turbo Prolog, Insight 2+, M.1, MicroExpert, and KnowledgePro formats.

KnowledgeMaker accepts data from Lotus 1-2-3 and databases and outputs IF... THEN statements, or you can use data from other programs and output rules in English. Lotus 1-2-3 files are read without an interface or conversion procedure.

Both KnowledgeMaker and KnowledgePro run on IBM PCs, XTs, ATs, and compatibles with MS-DOS or PC-DOS 2.1 or higher, 512K bytes of RAM, and two floppy disk drives, although the company recommends a hard disk drive. KnowledgePro also comes with source code, and it is not copy-protected.
Price: KnowledgePro, $495; KnowledgeMaker, $99.
Contact: Knowledge Garden Inc., 473A Malden Bridge Rd., Nassau, NY 12123, (518) 766-3000.
Inquiry 587.



Hypertext in operation as part of KnowledgePro.

Microsoft Announces Works for the PC

PC-Works combines word-processing, spreadsheet, database, reporting, charting, and communications modules, along with graphics, a spelling checker, and macros. You can copy data between modules or receive information over the communications module and place it in another module.

The word-processing module is basically Word 2.0, according to Microsoft, but without the style sheets, glossaries, divisions, and multiple columns. It has an undo command and a mailing-label facility, and it features the same font support and printer drivers as Microsoft Word.

The spreadsheet, which has 256 columns by 4096 rows, functions like Lotus 1-2-3. It offers names, macros, and freeze-title capabilities. PC-Works does not include such Lotus 1-2-3 features as tables, distribution ranges, automatic series, and label-range justifications, but it does provide numeric alignment, cell printing styles, and the ability to print in different fonts.

The charting interface, which is also similar to that of 1-2-3, lets you chart worksheets with overlapped bars and line charts with different scales. Eight graph types are included.

With the report module, you can break up reports into three levels and perform several statistical functions, including cumulative or noncumulative functions over any break level. Summary reports are also an option.

The in-memory and nonrelational database allows 4096 records and 256 fields and features form and list views. Also allowed are calculated fields, Boolean logic, and three concurrent sorts.

The program runs in character mode rather than graphics mode in all modules except charting. PC-Works uses pull-down Windows-like menus, and the mouse is supported for selection, scrolling, and command or dialog item selections. Communications facilities include autologon, VT-100, and Xmodem.

PC-Works is designed to run on 8086/8088 IBM PCs and compatibles with 512K bytes of RAM, two 360K-byte floppy disk drives or one 720K-byte drive, and a CGA or Hercules card. The program is not copy-protected.
Price: $195.
Contact: Microsoft Corp., P.O. Box 97017, Redmond, WA 98073-9717, (206) 882-8080.
Inquiry 588.

C Library

C-Worthy from Solution Systems is a C library that works with most C compilers. The program-callable subroutines and development utilities automate program-development tasks.

Screen display of text, error messages, and help screens are held in separate files. Windowing facilities make use of virtual screens as well as physical screens. Keyboard-handling routines offer text windows that describe the next step. A word-wrapping text editor is featured, along with pop-up, Lotus-style, and Windows-style menus. Error checking is done automatically with a call to a single library routine. A DOS interface acts as the interface to the operating system and takes care of such functions as setting date and time through the locking of a variable-length record in a file.

Solution Systems reports that C-Worthy runs on IBM PCs and compatibles, PS/2 machines, and incompatible MS-DOS-based systems.
Price: $295; $495 with source code.
Contact: Solution Systems, 541 Main St., Suite 410, South Weymouth, MA 02190, (800) 821-2492; in Massachusetts, (617) 337-6963.
Inquiry 589.

continued

Under-$2000 80386 System

Advanced Logic Research's 80386 product line includes the ALR 386/2 Model 10, a $1990 system. The Model 10 includes 1 megabyte of 32-bit 80-nanosecond RAM, expandable to 2 megabytes on the system board. Also included is a single 1.2-megabyte floppy disk drive, single serial and parallel ports, and a Phoenix BIOS.

In addition to the entry-level Model 10, the 386/2 is available as Models 40, 80, and 130, with hard disk drives of corresponding capacities. All have 2 megabytes of RAM and a hard disk controller that features 1-to-1 interleave and on-board caching.

All models of the 386/2 come with 101-key keyboards and eight full-length expansion slots: two 32-bit, four 16-bit, and two 8-bit. Optional accessories include an EGA and a high-resolution color monitor.
Price: $1990; with 40-megabyte hard disk drive, $3990; with 70-megabyte drive, $4690; with 130-megabyte drive, $7299.
Contact: Advanced Logic Research Inc., 10 Chrysler, Irvine, CA 92718, (714) 581-6770.
Inquiry 590.

High-Speed, Low-Cost Workstation

Sun Microsystems' Sun-3/60 is a 68020-based Unix system that runs at 3 million instructions per second (MIPS) and can be expanded to 24 megabytes of main memory. The company claims that using the Dhrystone benchmark, the 3/60 performs at approximately three times the speed of the VAX-11/780.

In addition to the 20-MHz 68020, the 3/60's standard configuration includes a 68881 floating-point coprocessor, 4 megabytes of 200-nanosecond RAM, two RS-423C serial ports, an SCSI port, and both standard and thin-cable Ethernet interfaces. Mass storage options include 71- or 141-megabyte hard disk drives and a 60-megabyte tape-backup unit. Also standard is an optical mouse.


The Sun 3/60 runs at 3 MIPS and can take 24 megabytes of RAM.

Both color and monochrome display options are available, including three monochrome monitors with resolutions of up to 1600 by 1280. Both 16-inch and 19-inch color monitors are available, with 1152- by 900-pixel by 8-bit resolution, along with a monochrome plane.

In addition to the Unix operating system, the 3/60 includes the SunPro programming environment, the SunView window-management and interface-development system, and the SunCore and SunCGI graphics libraries. Also available is the SunGKS graphics library, as well as C, FORTRAN-77, Pascal, and Modula-2.
Price: Entry-level diskless system, $4995; with 141-megabyte hard disk drive and tape backup, $12,400.
Contact: Sun Microsystems Inc., 2550 Garcia Ave., Mountain View, CA 94043, (415) 691-1300.
Inquiry 591.

Heavy-Duty AT-Compatible

Designed for withstanding hazards and harsh environments, the Heath/Zenith SW-3000 is an IBM PC AT–compatible, 80286-based system that operates at 8 MHz with no wait states. The system's standard features include 512K bytes of RAM, a single 1.2-megabyte floppy disk drive, and a 20-megabyte hard disk drive. A socket for an optional 80287 numeric coprocessor is included as well.

Other standard features of the SW-3000 include serial and parallel ports, six expansion slots, and a video card that supports monochrome display adapter–, CGA-, EGA-, and Hercules-compatible displays.

The SW-3000 can be rack-mounted for laboratory or production-area use. A filtered fan maintains positive air pressure within the cabinet to keep dust and dirt from entering, and the keyboard is impervious to dust, dirt, and liquids.

Along with the computer, you'll need an SW-3010 Industrial Monitor, a 13-inch EGA-compatible monitor that supports dual-scan frequency outputs of 15.75 kilohertz and 21.8 kHz for resolution of up to 640 by 350 pixels. The monitor is housed in a metal cabinet, and, like the computer, it has a filter-equipped fan that maintains positive air pressure. It's also rack-mountable.
Price: SW-3000, $4500; SW-3010, $900.
Contact: Heath/Zenith, Computer-Based Instruments, Hilltop Rd., St. Joseph, MI 49085, (616) 982-3200.
Inquiry 592.

TI Upgrades Explorer

Texas Instruments' Explorer II system is built around TI's proprietary 32-bit Explorer Lisp microprocessor. The company claims the system provides more than 5 times the performance of previous Explorer systems. The Explorer Lisp microprocessor integrates 60 percent of the original two-board Explorer processor onto a single custom chip, packing more than 553,000 transistors into a 1-square-centimeter area, more than 2.5 times as dense as the 68020. Pipelined architecture provides execution of microinstructions and many of the more complex Lisp macroinstructions in a single clock cycle.

The Explorer II system integrates Lisp and Unix by combining an Explorer II processor with a 68020 processor running Unix System V. The Explorer II processor comprises the Explorer Lisp Microprocessor, 32,000 words of writable control store, and two high-speed cache memories.

The system includes a three-button mouse and a 17-inch monochrome monitor with 1024- by 808-pixel resolution.

Owners of the original Explorer systems can upgrade their systems with the Explorer II processor kit.
Price: $49,900 to $99,900; processor upgrade, $20,000.
Contact: Texas Instruments Inc., Data Systems Group, P.O. Box 809063, DSG-141, Dallas, TX 75380-9063, (800) 527-3500.
Inquiry 593.

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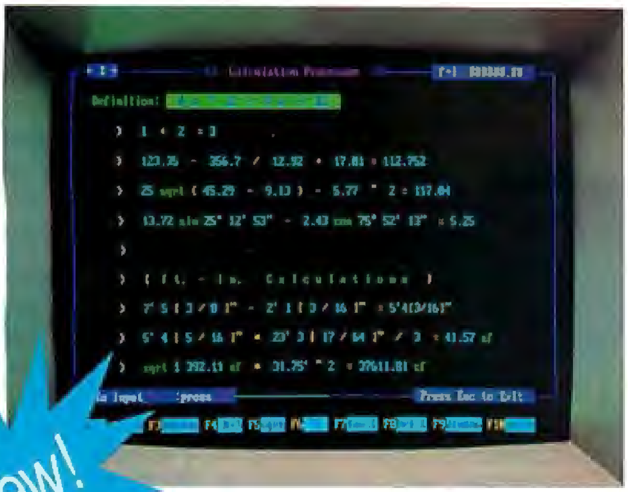

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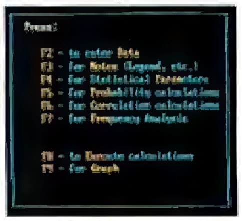

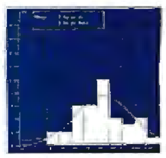

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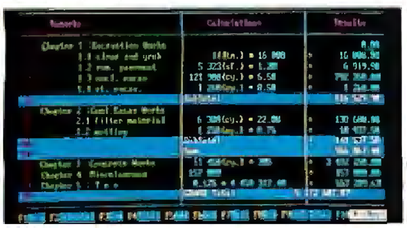

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System requirements ■ For IBM PC/XT/AT or fully compatibles.
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PERIPHERALS

Floppy Disks with 5.5 Megabytes

Based on Kodak's 6.6-megabyte high-density floppy disk drive, the Pelican 6.6 stores 5.5 megabytes (formatted) of data on special Verbatim floppy disks. The Pelican includes a high-speed controller card with 512K bytes of its own cache memory. By buffering data to and from the drive, the cache gives the system an effective access time of 85 milliseconds.

The drive uses hard disk-type head positioning and stores 384 tracks per inch. Data-transfer speed is 500,000 bits per second. The Pelican will read from (but not write to) 3.3-megabyte, 1.2-megabyte, and 360K-byte disks.

Both an internal mount and an external Pelican are available. The internal Pelican fits into any half-height slot and uses the computer system's internal disk drive. The external model, which has a 2¼-inch-wide footprint, has its own power supply and cooling system.

Price: Internal, $695; external, $895; disks, approximately $20 each.
Contact: Pacific Micro Systems, 160 Gate 5 Rd., Sausalito, CA 94965, (415) 331-2525.
Inquiry 594.

The Pelican 6.6 stores 5.5 megabytes on a special floppy disk.

High-Speed Daisy-Wheel Printer

Primages' 90-GT is a daisy-wheel character printer that prints at 90 characters per second. The printer has a ribbon-sensing system that automatically shuts it down if a ribbon breaks.

The company offers several 100-spoke wheels in a wide variety of type styles. Each wheel is capable of printing in 12 languages. Sheet and envelope feeders are also available.

Price: $1095.
Contact: Primages Inc., 151 Trade Zone Dr., Ronkonkoma, NY 11779, (516) 585-8200.
Inquiry 595.

Desktop Modem Uses MNP

With the introduction of its MultiModem212E, MultiTech Systems has added hardware-based MNP error-detection and retransmission protocol to its 300-/1200-bps desktop modem.

The Hayes-compatible MultiModem212E can operate both synchronously and asynchronously. It can be set to run with or without MNP or to auto-detect MNP. According to the company, use of MNP will pass up to 10 percent more data through a connection in a given period of time.

Price: $399.
Contact: MultiTech Systems, 82 Second Ave. SE, New Brighton, MN 55112, (800) 328-9717; in Minnesota, (612) 631-3550.
Inquiry 596.

High-Speed Personal Laser Printer

The Model L1012 Personal Laser Printer is a 12-page-per-minute unit from Printronix. It emulates the HP LaserJet Plus, the Diablo 630, and the Epson FX-80 and comes with nine typefaces, each available in both normal and bold.

Toner life is 2000 pages, developer and drum life is rated at 15,000 copies, and the optical filter and fusion unit has a rated life of 45,000 copies. The printer is shipped with Quickset, a configuration software package.

Price: $3495.
Contact: Printronix, 17500 Cartwright Rd., P.O. Box 19559, Irvine, CA 92713-9559, (714) 863-1900.
Inquiry 597.

Overhead Palette Shows Color

Telex Communications' MagnaByte 5220-I is a computer-interfaced LCD for overhead projectors that has a new twist: color. The display takes the color output from an IBM PC or compatible and turns it into an approximate LCD color image for overhead projection. It will also work with monochrome-only systems, projecting graphics in deep blue and yellow.

No special software is required for the MagnaByte. It comes complete with an LCD screen, a full-length plug-in board, and a slide-projector-like remote control. The display weighs 6½ pounds and is fan-cooled.

Price: $1580.
Contact: Telex Communications Inc., 9600 Aldrich Ave. S, Minneapolis, MN 55420, (612) 884-4051.
Inquiry 598.

Shadow Boasts Redundant Disks

The Shadow is a high-capacity redundant data-storage system designed for use with IBM PC ATs and compatibles, the Macintosh, and Digital Q-Bus-based systems.

Consisting of dual 86-megabyte or 170-megabyte hard disk drives, the Shadow also has two separate controllers and two separate power supplies. All data is simultaneously written to both disks.

If either a disk, controller, or power supply fails, the data continues to be read from and written to the other disk with no interruption and no loss of data.

The company reports that the average access speed is under 30 ms.

Price: Dual 86-megabyte drives, $4395; dual 170-megabyte drives, $5995.
Contact: Century Data Systems, Ford/Higgins Division, 1301 South Sunset St., Longmont, CO 80501, (800) 262-6743; in Colorado, (714) 999-2664.
Inquiry 599.

TurboVision Offers Big-Screen View

AST Research's TurboVision is a combination high-resolution graphics board and high-resolution full-page monitor designed primarily for desktop-publishing applications with IBM PCs, XTs, ATs, and compatibles.

TurboVision's 15-inch full-page display has a resolution of 1024 by 1280 (108 pixels per inch) and uses "paper-white" phosphors. The monitor has a 107-MHz bandwidth, a 79.6-kHz scan rate, and a 60-hertz noninterlaced refresh rate.

Price: $1995.
Contact: AST Research, 212 Alton Ave., Irvine, CA 92714, (714) 863-1333.
Inquiry 600.

continued

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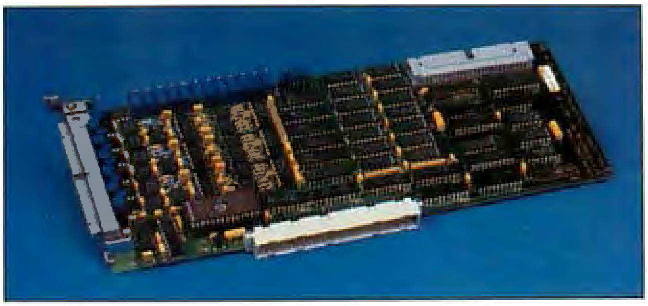

National Instruments' NB-AO-6 adds six DACs to the Mac II.

Providing test signals and generating waveforms for automated test equipment are two typical applications for which National Instruments' NB-AO-6 analog output board is designed. The board plugs into the Macintosh II's NuBus and features six 12-bit D/A converters.

Both unipolar and bipolar voltage outputs are available for each converter. National Instruments says each voltage output settles to within one-half least significant byte of full scale (10 volts) within 4 microseconds.

The NB-AO-6 features a high-performance real-time system integration (RTSI) bus interface that allows synchronization with processes on other NB series boards. The converter outputs can be updated by an RTSI bus signal, an external signal, or by software control.

The board allows you to supply references voltages between −10V and 10V, providing the capability for four-quadrant multiplication. Data can be written to any combination of D/As simultaneously with standard 16-bit write operations.
Price: $895.
Contact: National Instruments, 12109 Technology Blvd., Austin, TX 78727-6204, (800) 531-4742; in Texas, (800) 433-3488 or (512) 250-9119.
Inquiry 601.

Meanwhile on the Mac II front, AST Research has released an intelligent communications processor that offloads I/O processing from the Mac's 68020. The AST-ICP has a 68000 processor running at 8 MHz, 512K bytes of zero-wait-state RAM, and either two or four synchronous/asynchronous serial ports.

AST says the board provides a foundation for multiuser, multitasking environments through Unix. In addition, two of the ports can be configured to work with AppleTalk, giving developers the opportunity to create links between AppleTalk networks.

The AST-ICP plugs into the Mac II's NuBus and provides support for full NuBus arbitration. It can be configured with up to 64K bytes of EPROM.
Price: Two-port version, $949; four-port version, $999.
Contact: AST Research Inc., 2121 Alton Ave., Irvine, CA 92714, (714) 863-1333.
Inquiry 602.

386 Board for the PC

The PC-Elevator 386 is a full-length plug-in board that turns any IBM PC, XT, AT, or compatible into an 80386-based system. The board runs at 16 MHz with no wait states and includes 1 megabyte of 100-nanosecond RAM that can be expanded to a maximum of 16 megabytes using daughterboards.

According to the manufacturer, the PC-Elevator doesn't require any modifications of the host machine for installation. The 80386 processor works in tandem with the system's processor, using the original chip to handle I/O processing.
Price: $1995.
Contact: Applied Reasoning Corp., 86 Sherman St., Cambridge, MA 02140, (617) 492-0700.
Inquiry 603.

Two Megabytes for the Amiga

The latest addition to Micron Technology's line of add-on memory boards is a 2-megabyte version for all Amigas, including the 500, the 1000, and the 2000 models. If you have an Amiga 2000, you can insert the board directly into a motherboard expansion slot. If you have an Amiga 500 or 1000, you'll need an optional expansion chassis.
Price: $495; expansion chassis, $55.
Contact: Micron Technology Inc., Systems Group, 2805 East Columbia Rd., Boise, ID 83706, (800) 642-7661; in Idaho, (208) 386-3800.
Inquiry 604.

PC Multiuser System

QuickLink is a hardware/software system that turns an IBM PC, XT, AT, or compatible into a multiuser, multiprocessor MS-DOS system running under the Novell Netware operating system.

The basic hardware component of the system is the QuickLink card, a full-length expansion card that's essentially an IBM PC on a circuit board, complete with an NEC V40 processor and 768K bytes of RAM.

A standard IBM PC-compatible ASCII terminal connects to the QuickLink card using standard twisted-pair telephone wiring. Each terminal and QuickLink card becomes a complete MS-DOS workstation. Up to 51 stations can be configured on a single system.

According to its manufacturer, QuickLink is a closely coupled local area network that uses the high-speed bus of the main system to interconnect the multiple processors instead of the serial cables used in most LANs.

For those looking for growth beyond 51 stations, multiple IBM PC file servers can be interconnected. The Network Link claims that QuickLink is compatible with most off-the-shelf LAN interface cards, communication servers, and mainframe gateways. QuickLink is compatible with COM1 and COM2 for printer and modem hookup. I/O ports are user-selectable via DIP switches.
Price: $1095.
Contact: The Network Link, 3303 Harbor Blvd., Bldg. H-10, Costa Mesa, CA 92626, (714) 549-9380.
Inquiry 606.

Micro Channel Prototype Board

For those who have an uncontrollable urge to work on their own hardware for the IBM PS/2 Micro Channel bus, a company by the name of 29 Industries has developed two different PS/2 prototype boards.

Both single-layer and four-layer boards are available. The four-layer board has separate power and ground planes, with top-row through holes of +5V and a bottom row of ground connections. Both boards have 3500 tin lead reflow holes, each with 0.035-inch on 0.1-inch centers. Bus connectors on both boards are gold-plated.
Price: Single-layer, $39.95; four-layer, $59.95.
Contact: 29 Industries Inc., 6190 North Federal Highway, Boca Raton, FL 33431, (305) 994-9229.
Inquiry 605.

continued

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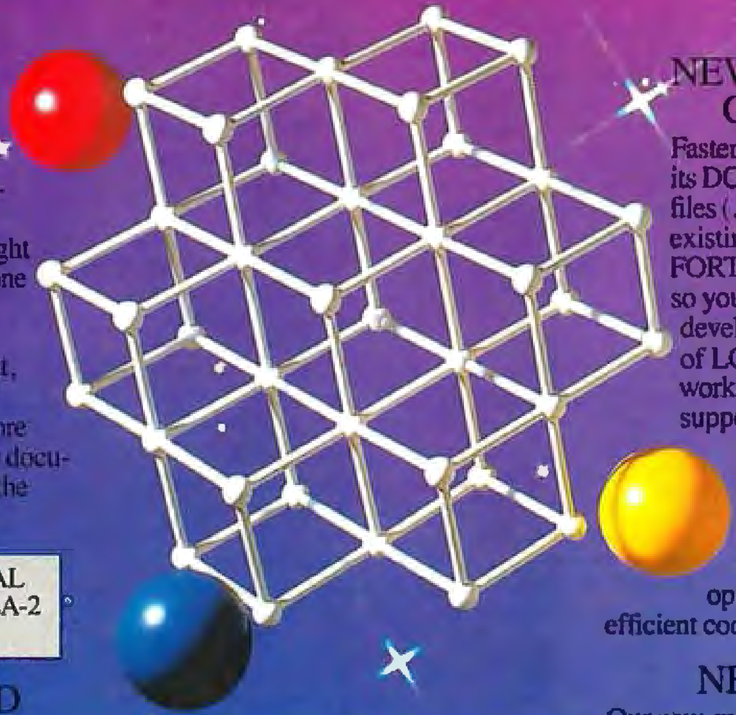

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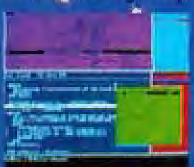

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SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

Pascal for the Apple IIGS

ORCA/Pascal, an implementation of ISO standard Pascal, offers over 60 built-in procedures and functions. Extensions include UCSD-style strings, bit-manipulation operators, and extensions for systems and scientific programming. You can run ORCA/Pascal in stand-alone mode or install it under the Apple Programmer's Workshop or ORCA/M for the Apple IIGS shells. Access to the Apple IIGS Toolkit is provided, and the program features directives to control large or small memory models.

According to Byte Works, ORCA/Pascal runs the Sieve of Eratosthenes benchmark in 5.4 seconds on the Apple IIGS.

Price: $125.

Contact: Byte Works Inc., 4700 Irving Blvd. NW, Suite 207, Albuquerque, NM 87114, (505) 898-8183.

Inquiry 607.

Pascal Source Tool

TurboRef 4.0, a $49.95 cross-referencing and listing utility, assists in locating variable names and mapping logical structures in Pascal source code.

The lister encloses control blocks in boxes and indicates the current procedure name for each source line and the source file for each line. You can highlight comments in bold, as well as underline reserved words.

The cross-reference utility lists the line number for each use of variables and constants, and it lists the type of use for each reference. You can upshift lowercase names or reference them separately. You can also process a list of files for separate or combined cross-references; with multiple source files, you can list the filename with each reference.

Version 4.0 features separate printer-configuration files, enabling you to use virtually any printer, Gracon reports. The addition of block reads and writes has increased the speed of execution with this new version.

TurboRef 4.0 runs on IBM PCs with 128K bytes of RAM, MS-DOS 2.0 or higher, and a Pascal compiler from Borland, Microsoft, or Software Building Blocks.

Price: $49.95.

Contact: Gracon Services Inc., P.O. Box 340, Haslett, MI 48840-0340, (517) 349-4900.

Inquiry 608.

COBOL Productivity Tool

ProCode the Development Tool (PCDT) is a COBOL programming tool that creates debugged ANSI COBOL 74 source code and runs it through a compiler. PCDT lets you generate COBOL program shells and data-definition logic at a rate of 3000 lines per minute, ProCode reports. You can create custom screens and on-line help for each data-definition field.

PCDT runs on MS-DOS- or PC-DOS-based systems with at least 256K bytes of RAM. A hard disk drive is recommended, but not necessary to run the program.

Price: $995.

Contact: ProCode, 859-44 State Rd. 436, Casselberry, FL 32707, (305) 699-6799.

Inquiry 609.

80386 BASIC Compiler

True BASIC's 386 BASIC compiler includes an implementation of Phar Lap's Run386. Features and syntax are identical to version 2.0 of True BASIC, but with the 80386 version you can create megabyte-long strings and perform matrix algebra with arrays that completely fill memory, the company reports. The 80386 version will also support the 80387 microprocessor.

Price: Under $500.

Contact: True BASIC Inc., 39 South Main St., Hanover, NH 03755, (603) 643-3882.

Inquiry 610.

Programming on the Commodore 64 and 128

Designed to facilitate application development for GEOS, geoProgrammer offers an assembler, linker, and symbolic debugger. The assembler reads source text from documents created with geoWrite, a WYSIWYG word processor that enables you to place comments in bold or italics or paste a picture from geoPaint. The graphics appear as pictures in the listing instead of just numbers. The assembler supports standard 6502 assembly language mnemonics and addressing modes, and you can design over 1000 labels for each assembly module.

Expressions can include a combination of arithmetic and logical operators. A macro facility supports nested invocation and multiple arguments. Pseudo-operators are incorporated into geo-Assembler for conditional assembly, memory segment-type definition, and space allocation.

The linker accepts link structure from geoWrite documents and reads relocatable object modules produced by geoAssembler. It supports GEOS SEQ-type and VLIR applications, resolves cross-references, and evaluates unresolved arithmetic and logical expressions passed from the assembler. Error messages are placed in geoWrite documents, and executable files are created.

The debugger transforms the RAM Expansion Unit into a monitor so that you can debug applications with the maximum available memory. It also features memory examination and modification commands, including symbolic line disassembly and a line assembler for patching codes. Results are printed into an overlay text window.

Price: $69.95.

Contact: Berkeley Softworks, 2150 Shattuck Ave., Berkeley, CA 94704, (415) 644-0883.

Inquiry 611.

Prolog Knowledge Base Manager

BridgeWare is a stand-alone application that lets you create Prolog databases that you incorporate as knowledge bases into expert systems. It works with ASCII files, or it can access data from other programs or languages. It can also combine information from several applications into a single knowledge base.

BridgeWare's Schema editor lets you create and maintain your knowledge base with full-screen and visual editing of files and terms, management of linked files, formats for parsing ASCII text files, and a print function.

The program is compatible with Edinburgh, Turbo, and ExperProlog. Example programs and data are included for languages and programs including BASIC, C, Pascal, dBASE II and III, Lotus 1-2-3, and Symphony.

To run BridgeWare you need an IBM PC, AT, XT, or compatible with MS-DOS or PC-DOS 2.1 or higher.

Price: $69.95.

Contact: MicroBase Software Systems Inc., Medford Office Center, Old Marlton Pike, Medford, NJ 08055, (609) 654-7394.

Inquiry 612.

continued

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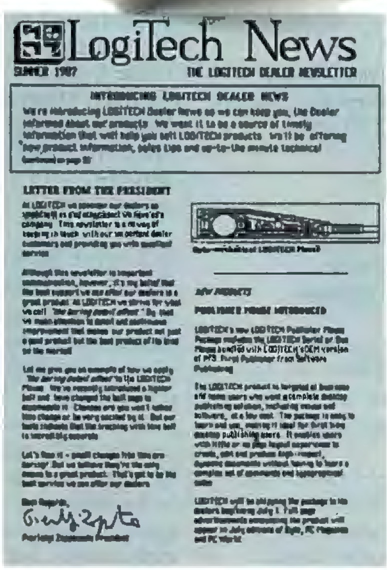

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Plot and Display Stresses with CPLOT

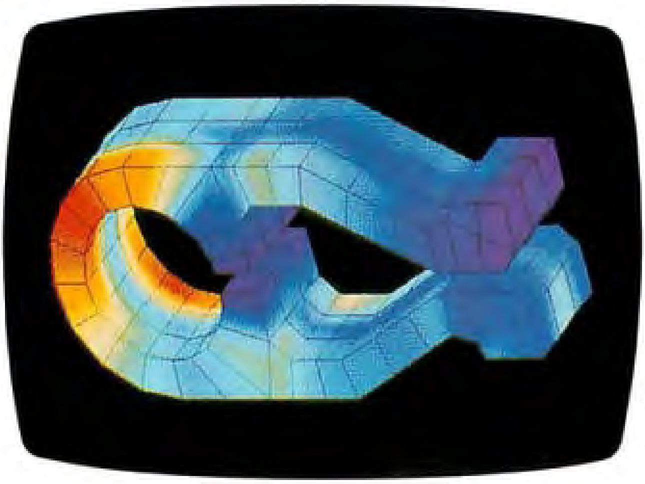
Part of Algor's Supersap finite-element stress, dynamic, and heat-transfer modeling and analysis system, CPLOT enables you to plot and display stress, displacement, temperature, and heat flux.

The program uses the shading technique of dithering to display stress, temperature, and other contours. The technique uses patterns of different-color pixels to simulate intermediate colors on a computer screen. Dithering enables you to see 33 shades of color with a CGA (with only 4-color capability). With an EGA, dithering can turn seven colors into 97, with 15 shades between each base color.

With CPLOT you can see a graphic display of the stress or thermal state and yield criteria stresses, such as Von Mises or Tresca stresses. You can view plots of stress-contour lines, iso-stress lines, shaded stress contours, superimposed stress-contour lines, and shaded contours.

The program uses colors to represent degrees of stress, and you can change the color mapping to suit your needs.

CPLOT runs on IBM PCs and compatibles and requires MS-DOS or PC-DOS 2.0 or higher.
Price: $995.
Contact: Algor Interactive Systems, Essex House, Essex Square, Pittsburgh, PA 15206, (412) 661-2100.
Inquiry 613.



CPLOT displays stress, displacement, and temperature.

A Calculator for Your PC

The Lascaux1000 is based on a model of a pocket calculator. It uses dimensional analysis, which is the recognition of physical quantities rather than just numbers. You can enter the units of measurements you want calculated, along with numbers, and the calculator performs the conversions. It recognizes over 150 units of measurement and has a table of over 200 constants used in physics, chemistry, and engineering. You can also expand and customize its internal tables.

What you see on-screen looks like a calculator, with the paper tape scrolling above it. You can view the full length of paper tape on screen or output it to your printer.

The Lascaux1000 runs on IBM PCs and compatibles with at least 320K bytes of RAM.
Price: $59.
Contact: Lascaux Graphics, 3220 Steuben Ave., Bronx, NY 10467, (212) 654-7429.
Inquiry 614.

Science Study through Software

Students can study biology and physics on their computers with software from Mindscape and Brøderbund.

That's Life: Explorations and Simulations in Biology lets students in grades seven through 10 explore human physiology, field ecology, applied genetics, and comparative zoology. Students can participate in adventure programs or simulations. The adventure programs include Human Body Exploration and Comparative Physiology Exploration, and the simulations include Applied Genetics Simulation and Field Ecology Simulation. Students participate in the research process, developing their scientific research and deductive-reasoning skills.

Mindscape reports that the program correlates to 15 life science and biology texts, a list of which is provided.

That's Life runs on Apple IIs with at least 64K bytes of RAM.
Price: $175.
Contact: Mindscape Inc., 3444 Dundee Rd., Northbrook, IL 60062, (312) 480-7667.
Inquiry 615.

Brøderbund's Physics is another interactive educational program, and it lets students experiment with manipulating vectors, interpreting graphs, and answering over 300 problems. They can also study orbital motion by experimenting with velocity and position. The program provides hints, further explanations, and answers to problems when necessary.

Physics runs on 512K-byte Macintoshes with external disk drives, as well as on the 512E Mac, Mac Plus, and SE.
Price: $99.95.
Contact: Brøderbund Software Inc., 17 Paul Dr., San Rafael, CA 94903-2101, (415) 479-1700.
Inquiry 616.

Math-Processing Software

The Professional Wheel Calculation Processor is a math program that lets you perform many different kinds of mathematical and scientific calculations in an interactive environment. It runs on the IBM PC, XT, AT, or compatibles with PC-DOS or MS-DOS 2.0 or higher, one floppy disk drive, and 384K bytes of RAM.

The program includes a full-screen editor with built-in mathematical functions and a library that lets you create your own library of formulas and functions that you can call readily for later use. Functions and other calculations can be documented for future reference. You can analyze functions by calculating individual or incremental values, derivatives, or integrals, as well as by plotting.

The program can also calculate statistical probabilities, correlations, and frequency analysis. In addition, it performs conversions of commonly used units of measure for length, area, volume, weight, and temperature.

Certain features are available as pop-up utilities. These include the unit-conversion utility and two calculation processors that are capable of repetitive calculations and can call user-defined functions and constants.
Price: $158.95 until October 30; $199.95 thereafter.
Contact: Dalin Inc. Applications Software, 16421 Clymer St., Granada, CA 91344, (818) 360-7058.
Inquiry 617.

continued

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SOFTWARE • BUSINESS AND OTHER •

Map Information Display and Analysis System

With MIDAS you can locate street addresses and display a map from raw data or from a database. The program supplies maps of over 300 U.S. metropolitan areas, including names of every street, river, and bridge, as well as address number ranges for every block and side of a street. You can create your own map using the keyboard, a mouse, or a digitizer.

MIDAS can also show boundary designations, such as city, town, and county borders, or you can designate your own. You can use the boundary features to search for data points within a border, determine what boundaries a given point lies within, or overlay different boundaries. A zoom-in/zoom-out function is also available.

The program runs on IBM PCs, XTs, ATs, and compatibles with 640K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a hard disk drive. A color graphics monitor is recommended, along with a full-color plotter; however, MIDAS works with monochrome adapters and supports most printers and plotters. MapInfo also recommends dBASE III Plus or a similar database program.
Price: $750; metropolitan area maps cost between $300 and $2000.
Contact: MapInfo, Hendrick Hudson Building, 200 Broadway, Troy, NY 12180, (518) 274-8673.
Inquiry 618.

MIDAS displays geographical data in black and white or color.

Text Editor for the Amiga

CygnusEd combines word-processing and programming features, including auto-indent and macro keys. Designed to be used with a mouse or keyboard, it is written in assembly language. To run the program, you need an Amiga 500, 1000, or 2000 with at least 512K bytes of RAM.

With CygnusEd you can edit multiple files simultaneously and see multiple views of the same files, use intuitive commands and macros, run from the CLI or Workbench, set margins, and use word-wrap functions.
Price: $30.
Contact: CygnusSoft Software, P.O. Box 363, 1215 Davie St., Vancouver, B.C., V6E 1N4 Canada, (604) 688-1085.
Inquiry 619.

WordPerfect for the Amiga

WordPerfect for the Amiga supports multitasking, features pull-down menus, and lets you use the mouse or the keyboard. In addition, the Amiga's files are compatible with WordPerfect 4.1 for the IBM PC.

File-management features include a Look option and the ability to perform common file operations without exiting the program. You can rename, delete, print, or copy files. The Look option lets you preview the contents of a document, and a Search option displays only those files that contain a given word or phrase.

Other features of the program include footnotes and endnotes, macros, merging, paragraph and outline numbering, and table of contents and index generation.

A spelling checker with a 115,000-word dictionary includes a phonetic and word-template lookup. You can also create your own dictionaries, or import those created with WordPerfect on the IBM PC.

The thesaurus lets you display synonyms and antonyms for two words at the same time.

The program supports interlace mode but does not offer bit-mapped fonts.
Price: $395.
Contact: WordPerfect Corp., 288 West Center St., Orem, UT 84057, (801) 225-5000.
Inquiry 620.

VP-Planner Plus

Paperback Software's new version of VP-Planner has a word processor and graphics tools. With the program, you can also set up a multidimensional database via prompts.

VP-Planner Plus is compatible with Lotus 1-2-3 version 2.0, but it features a revised interface that is not like Lotus 1-2-3's.

The program runs on IBM PCs and compatibles with at least 256K bytes of RAM or 320K bytes when using multidimensional files. A CGA, EGA, or Hercules adapter is also required.
Price: $174.95.
Contact: Paperback Software, 2830 Ninth St., Berkeley, CA 94710, (415) 644-2116.
Inquiry 621.

Flying with Yeager

Chuck Yeager's Advanced Flight Simulator offers you the chance to test and fly in formation with real and experimental aircraft at Mach speeds, according to Electronic Arts.

Three levels of instruction are offered. The first teaches basics, such as takeoffs and landings; the second covers more advanced maneuvers, like aileron rolls and hammerhead stalls; and the third teaches acrobatic stunts. The latter prepares you to use the Formation Flying feature, in which you follow Yeager through obstacle courses and three-dimensional terrain. A flight recorder lets you create and store your stunt flying patterns.

A Test Pilot option offers a selection of 14 aircraft to check out, using actual test-pilot aircraft-evaluation charts.

The flight simulator runs on IBM PCs, XTs, ATs, and compatibles with MS-DOS or PC-DOS 2.0 or higher. The program supports CGA, EGA, and compatible graphics adapters. Electronic Arts reports that a Commodore 64/128 version is in the works.
Price: $39.95.
Contact: Electronic Arts, 1820 Gateway Dr., San Mateo, CA 94404, (415) 571-7171.
Inquiry 622.

EVENTS

October 1987

Commodore Show, Anaheim, CA. R.K. Productions, P.O. Box 18906, San Jose, CA 95158, (800) 722-7927; in California, (800) 252-7927. *October 3–4*

Buscon/87-East, Marlborough, MA. Edward E. Grazda, Director of Education, 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701-2750, (213) 402-1610. *October 5–7*

Computer Security Technology and Techniques, Berkeley, CA. Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151. *October 5–7*

1987 Nebraska Videodisc Symposium—Education: Discoveries and Decisions, Lincoln, NE. Videodisc Design/Production Group, P.O. Box 83111, Lincoln, NE 68501-3111, (402) 472-3611. *October 5–8*

Twelfth Annual DSSD User's Conference—Information Power: The Strategic Imperative, Kansas City, MO. Georganna Carson, Ken Orr & Associates Inc., 1725 Gage Blvd., Topeka, KS 66604-3379, (800) 562-8000; in Kansas, (913) 273-0653. *October 6–8*

Calgary Computer/Office Technology Show, Calgary, Alberta, Canada. Gary Gow, Calgary Computer/Office Technology Show, 1015 Centre St. N, Suite 200, Calgary, Alberta, Canada T2E 2P8, (403) 276-7881. *October 7–8*

Seventh Annual Educational Computer Fair: Computers—Tools Reshaping Education, Cleveland, OH. Alice Fredman, Educational Computer Consortium of Ohio, 1123 S.O.M. Center Rd., Cleveland, OH 44124, (216) 461-0800. *October 8–9*

Seventh Annual Symposium on Small Computers in the Arts, Philadelphia, PA. Richard Moberg, 338 South Quince St., Philadelphia, PA 19107, (215) 834-1511. *October 8–11*

Northeast Atari Computer Fair, Worcester, MA. Alan Glick, Boston Computer Society, One Center Plaza, Boston, MA 02108, (617) 296-8286. *October 9–11*

AmiEXPO, the Amiga Event, New York, NY. AmiEXPO Headquarters, 211 East 43rd St., Suite 301, New York, NY 10017, (800) 322-6442; in New York, (212) 867-4663. *October 10–12*

Computer Graphics of Fractals: Algorithms from the Frontiers of Research, Santa Clara, CA. Sally Thomas, University of California Extension, Carriage House, Santa Cruz, CA 95064, (408) 429-4985. *October 12–13*

Second Annual PC Expo, Chicago, IL. Jim Mion, 333 Sylvan Ave., Englewood Cliffs, NJ 07632, (800) 922-0324; in New Jersey, (201) 569-8542. *October 13–15*

Voice Information Services Industry: Progress and Prospects, Washington, DC. Information Industry Association, 555 New Jersey Ave. NW, Suite 800, Washington, DC 20001, (202) 639-8262. *October 14–15*

Computer Technology/Special Education/Rehabilitation, Northridge, CA. Dr. Harry J. Murphy, California State University–Northridge, Office of Disabled Student Services, 18111 Nordhoff St., Northridge, CA 91330, (818) 885-2578. *October 15–17*

Northeast Computer Faire, Boston, MA. The Interface Group Inc., 300 First Ave., Needham, MA 02194, (617) 449-6600. *October 15–17*

1987 International Symposium on Laboratory Robotics, Boston, MA. International Symposium on Laboratory Robotics, Zymark Corp., Zymark Center, Hopkinton, MA 01748-9990, (617) 435-9501. *October 18–21*

Interex North American Conference of Hewlett-Packard Technical Computer Users, San Jose, CA. Interex Conference Department, 680 Almanor Ave., Sunnyvale, CA 94086-3513, (408) 738-4848. *October 18–22*

Technetron '87: Integration—Meeting the Challenge, Boston, MA. International Society of Wang Users, Wang Laboratories Inc., Mail Stop 019-350, One Industrial Ave., Lowell, MA 01851, (617) 967-4322. *October 18–22*

Database Expo, Anaheim, CA. Engineering Information Inc., 345 East 47th St., New York, NY 10017, (800) 221-1044; in New York, (212) 705-7635. *October 19*

Conference on Data and Knowledge Systems for Manufacturing and Engineering, East Hartford, CT. Fred Maryanski, CSE Dept., U-155, Storrs, CT 06268, (203) 486-2584. *October 19–20*

APICS Thirtieth Annual International Conference and Technical Exhibit, St. Louis, MO. APICS Meetings Department, 500 West Annandale Rd., Falls Church, VA 22046-4274, (800) 368-3402; in Virginia, (703) 237-8344. *October 19–23*

Third Expert Systems in Government Conference, Washington, DC. Peter Bonasso, AI Director, Mitre Washington AI Center, 7725 Colshire Blvd., MS W952, McLean, VA 22102, (703) 883-6908. *October 19–23*

International Test and Transducer Instrumentation Exhibition and Conference, London, U.K. Trident International Exhibitions Ltd., 21 Plymouth Rd., Tavistock, Devon PL19 8AU, U.K., 822-4671. *October 20–22*

Computer Technology in Special Education and Rehabilitation, Minneapolis, MN. Closing the Gap Inc., P.O. Box 68, Henderson, MN 56044, (612) 248-3294. *October 20–24*

Conference on Computers and Law, Santa Monica, CA. Michael M. Krieger, P.O. Box 24619, Los Angeles, CA 90024, (213) 393-9910. *October 21–23*

Sixth National Print Quality Seminar, Bedford, MA. Frank Stefansson, Datek Information Services Inc., P.O. Box 68, Newtonville, MA 02160, (617) 893-9130. *October 25–27*

EDUCOM '87, Los Angeles, CA. Carol Parysz, EDUCOM, P.O. Box 364, Princeton, NJ 08540, (609) 734-1888. *October 27–30*

Applied Imagery Pattern Recognition, Washington, DC. Jane Harmon, 403 Argus Place, Sterling, VA 22170, (703) 351-2708. *October 28–30* ■

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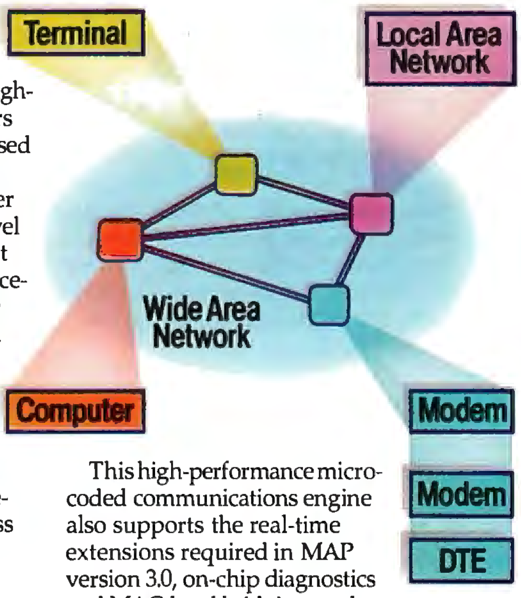

Motorola has developed a family of high-performance communications controllers called Serial Processing Units (SPUs) based on a modular design concept.

The MC68605 X.25 Protocol Controller (XPC) independently generates link-level commands for X.25 and X.75 networks. It expertly terminates the Link Access Procedure Balanced (LAPB) at the full 1.544 or 2.048 data rates provided by T1 facilities. It has passed rigorous Defense Data Network certification tests, and its global acceptance is suggested by use on packet networks all over Europe.

The MC68824 Token Bus Controller (TBC) is the only single-chip VLSI implementation of the IEEE 802.4 Media Access Control (MAC) sublayer defined in the Manufacturing Automation Protocol (MAP) specification.

This high-performance micro-coded communications engine also supports the real-time extensions required in MAP version 3.0, on-chip diagnostics and MAC-level bridging, and implements the recommended standard MAC-to-physical serial interface.

The MC68184 Broadband Interface Controller is, with RF circuitry, the broadband modem required for each node of a broadband MAP network.

In addition to the SPUs, M68000 communications peripherals include the MC68661 Universal Synchronous Communications Controller, the MC68652 Multi-Protocol Communications Controller, several DMA circuits and a variety of miscellaneous single- and multifunction devices. **A**

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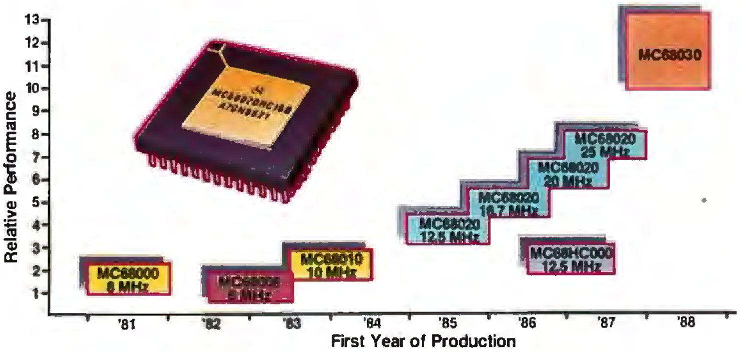

And, products based on M68000 Family MPUs are the standard for UNIX® operating systems, CAD/CAM workstations, next-generation office automation, multi-user/multi-tasking departmental computers, color graphics as well as for real-time factory automation.

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There are so many more reasons why the HDS-300 development station is the ultimate emulation and analysis tool for systems based on MC68000 Family processors. Discover them. **C**

Peripherals Today

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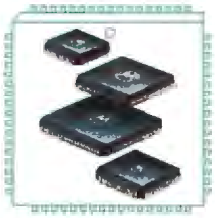
The MC68440 with dual independent DMA channels provides DMA control. System timing and parallel I/O requirements are handled by the MC68230. The MC68901 is a multifunction circuit with a single-channel UART for data communications, in addition to an 8-source interrupt controller, four 8-bit timers and eight parallel I/O lines.

Three different serial communications devices, MC68681, MC68661 and MC68652, complete the parts complement, and the kit also contains the documentation you'll want for converting these high-performance M68000 Family devices into superior systems of your own design.

The MC68000KIT is available only through authorized Motorola distributors. Contact your Motorola distributor to take advantage of this great $98 value. **D**

M68000 Family now offers surface-mount packaging.



As customers develop the ability to utilize surface-mount packages, Motorola is putting the M68000 Family in "J"-leaded, Plastic Leaded Chip Carriers. Several MPUs and over a half-dozen varied peripherals are already available now or later this year. The MC68000, MC68HC000 (HCMOS) and MC68010 are available now in the 68-lead package. The MC68008 is available now in the 52-lead version.

PLCC-packaged family peripherals include the MC68824 and MC68605 SPUs (84-lead), MC68440 and MC68442 DMA devices (68-lead), MC68681/2681 DUART (44-lead), MC68230 Programmable Interface/Timer (52-lead) and the MC68901 Multifunction circuit (52-lead). And this is only the beginning. **E**

Heralded Motorola M68000 Family training courses now available on audio cassettes.

Two Motorola-developed training courses for the MC68000 and MC68020 are now available on audio cassettes. Both of these low-cost courses also include course notes and appropriate technical literature.

Course MTTA1 is an overview of the MC68000 microprocessor: pins and bus operation, addressing modes, instruction set and exception processing including interrupts. Course completion offers you basic familiarity with the MC68000.

Course MTTA2 is an introduction to the MC68020: internal architecture, programming model, pins and bus operation, addressing modes, instruction set and exception processing.

MTTA1 is $60. MTTA2 is $95. The price for both courses together is $140.

A new course on the MC68030, MTTA3, is available in mid-September at $95. **F**

Literature Packs supply M68000 Family device and application information.

M68000 Family product literature has been assembled into three special, distinct assortments for differing interests. They include brochures, technical summaries and data sheets, benchmark reports, application notes, technical article reprints and other useful pieces.

The M68KPAK is the M68000 Family overview, from chips and software to board- and system-level products.

The M32BITPAK focuses on our top-o'-the-industry 32-bit products, featuring the MC68020, of course.

The M68KCOMPAK is oriented to the extensive M68000 Family communications capabilities. **G**

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ASK BYTE

Conducted by Steve Ciarcia

CAD Programs

Dear Steve:

I am looking into how to interface a computer-aided-design (CAD) program for an IBM PC-style computer with computer-numerical-control (CNC) machines. I would like to study the CNC programming practices and languages that are being currently used. I understand that MAP (manufacturing automation protocol), developed by General Motors, is gaining some acceptance.

I would be grateful for any sources you could give me to learn more about these or related subjects.

Thaddeus M. Sendzimir
Waterbury, CT

Basically, mechanical CAD packages produce a database containing all the dimensional information for the part. A separate program digests that database and produces a file that directs the CNC machine's motors to move the tool and workpiece in the right direction at the right time.

Unfortunately, there are no standards for the format of the CAD database, the instructions that the CNC tools expect to see, or the method you use to get the two talking together. That's the motivation behind MAP, which was supposed to set up some solid standards. Unfortunately, GM is finding that it's bitten off far more than it can chew: MAP is running into some serious schedule slips and general confusion.

One of MAP's big selling points was that it could connect everything to everything else. You might want to start out a lot smaller, with only a few tools at first. This gives you a chance to find out the advantages (and the problems) of complete automation without betting the whole company on someone else's ability to make everything work.

Fun though it is to play around making serious machinery take heavy cuts and spit big blue hot curly chips, I don't think this is a roll-it-yourself topic. There are too many subtle issues involved in getting it to work without wrecking something expensive along the way.

The general-purpose CAD program isn't suitable for this sort of work; you need full-blown three-dimensional solid modeling capability. The number of computations and display resolution required for that puts the hardware out of the PC or AT class and into the engineering workstation class. Of course, the price goes up along with the performance.

Probably the best starting point is to call up the folks who sell machine tools and pick their brains on CNC hookups. I suspect you'll find that they have a package that bolts a specific CAD package to a specific CNC machine, or perhaps to a family of similar machines. A general connection from a given CAD package to all the machines you're planning to use will be more difficult to get.

Ask what CAD programs are compatible with which CNC machines. When you get the same answer from more than one vendor, invite that CAD company in for a talk, and ask what tools they drive. Eventually, you'll figure out who's doing what. Ask for references, and be sure to follow them up: Talking with someone who's already done it is worth more than my advice any day. What you should be interested in is a complete packaged system rather than the details of exactly how the drawings get translated into tool paths. There are enough traps at your level to ruin your day.—Steve

Incompatible Compatibles

Dear Steve:

My organization bought a few Corona PCs because they were IBM PC-compatible. However, the staff encountered some problems when they created WordStar files on a Corona and tried to read them on IBM PCs or other compatibles.

Specifically, WordStar text files that were saved on a Corona and stored on a floppy disk seemed corrupted when they were read on IBM PCs or other compatibles: Part of a file (a page or a few paragraphs) would be missing or would be composed of peculiar characters. Sometimes WordStar would read in files other than the ones we specified.

Likewise, when a text file was created on other machines, it appeared corrupted when it was read by a Corona PC.

I would be grateful if you could help us identify the problem.

Yeo Pee Pin
Republic of Singapore

Your problem with WordStar files may be due to using different versions of DOS, the disk operating system, which you use to initially boot up the computer. The symptoms you describe appear when a disk created by DOS 2.0 or higher is used on a computer running DOS 1.0 or 1.1.

To avoid this type of problem, you should standardize on a later version of DOS (say 2.1) for all machines. Be sure that any system disks or boot disks used on the various computers are all DOS 2.0 or higher.

If this is not possible, remember that a computer running DOS 2.0 can use a disk created by DOS 1.1, but a computer running DOS 1.1 cannot use a disk created on a computer running DOS 2.0. You can determine the version of DOS running on a computer at boot time, when the DOS "signs on" with its version number. To determine under which version a disk has been formatted, use the CHKDSK *command. A disk formatted with DOS version 1.1 will report a disk capacity of 320K bytes (160K bytes if single-sided), while a disk formatted with DOS 2.0 or higher will report a capacity of 360K bytes (180K bytes if single-sided).*

To make use of WordStar files created under DOS 1.1, you should boot your computer with DOS 2.1 in drive A:, format a blank disk in drive B:, replace the disk in drive A: with the old disk containing your WordStar files, and then use the COPY *command to transfer your WordStar files on A: to the newly formatted disk in drive B:. You can then reformat the old*

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

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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.

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News about the Microsoft Languages Family

Optimizing Your Programs with the Microsoft® C Optimizing Compiler Version 5.0

Fast execution speed is the single most important feature of a C compiler. Volume 2, Number 2 of the Microsoft Languages Newsletter talked about the optimizations available in Microsoft C Version 4.0. Microsoft C Version 5.0 takes these optimizations further. For example,

```
for (i = 0; i < 25; i++)                becomes        tmp = a*b;
        array[i] = a*b;                                 for (i = 0; i < 25; i++)
                                                        array [i] = tmp;
```

Since a and b are not affected by the loop, they are moved outside of the loop. This optimization is called *invariant code motion.* The Microsoft C Optimizing Compiler also uses instructions available on the 8086 to optimize specialized loops. Initialization and memory movement loops are two examples. The optimizer generates REP STOSW and REP MOVSW instructions for

```
int i, x[25];                           and            int i, x[25], y[25];
for (i = 0; i < 25; i++)                               for (i = 0; i < 25; i++)
        x[i] = 0;                                              x[i] = y[i];
```

The following example is more complicated. The optimizer rewrites array references as pointer references because they are more efficient.

```
int i, x[25];                           becomes        int i, x[25], *ptr;
for (i = 0; i < 25; i++)                               for (i = 0, ptr = x; i< 25; i++, ptr++)
        x[i] = i*4;                                            *ptr = i*4;
```

Then the optimizer puts key variables in registers using *loop enregistering* and changes the loop incrementation using a process called *strength reduction.* The loop becomes

```
int i, x[25];
i = 25;
{
        register int j;
        register int *ptr;
        for (j = 0, ptr = x; j < 100; j + = 4, ptr++)
                *ptr = j;
}
```

The final form of the loop uses registers for key values and exchanges addition instructions for multiplication instructions.. Here is the output of the Microsoft C Optimizing Compiler in 8086 assembly code.

```
        mov     WORD PTR [bp-52], 25        ; set final value of i to 25
        mov     di,bp
        sub     di,50                       ; load pointer to x
        sub     si,si                       ; set temporary register variable to 0
                                            ; this variable is used as the loop counter
$L20000:
        mov     WORD PTR [di], si           ; set the array value
        add     di,2                        ; increment pointer by 2
        add     si,4                        ; increment loop counter by 4
        cmp     si,96                       ; check if we are at the end of the loop
        jle     $L20000
```

What is the result of these optimizations? Programs compiled with Microsoft C Version 5.0 run 15 to 30 percent faster than those compiled with Version 4.0.

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.
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Look for the Microsoft Languages Newsletter every month in this publication.

Microsoft

disk under DOS 2.1 for future use.

I hope this helps solve your problem.
—Steve

Driven Crazy by Drivers

Dear Steve:

Someone has said: "Only the rich can afford to buy anything cheap, because if it does not suit their needs, they can simply throw it away." This is so true for those of us who love computers but do not have the time or the inclination to program them. I find it particularly true of printer drivers.

I need a driver or other instructions to use the full power of both the Amiga and my new Panasonic KX-P1092 printer. I also have Micros System's Scribble 2.0 (an excellent value, by the way). I need a printer driver that is simple enough for a novice to install. Hopefully, one driver will work with both Scribble and the Amiga.

George Offenbacher
Port Clinton, OH

To use your Panasonic printer with the Amiga, you need an Epson printer driver. Fortunately, this driver is included with your system, and you can select it from the Preferences menu. Just change the printer selection to Epson, and your printer should work fine. Be sure to save your preferences after you make the change.—Steve

CB86 and Cursor Keys

Dear Steve:

I have some programs written in CB80, Digital Research's 8-bit compiled-BASIC language. I have recompiled these programs under CB86 to run on the Compaq computer. Everything works fine, except that I cannot read the cursor keys. I think that the Compaq is sending an ASCII 0 followed by another character whenever I press a cursor key, but that the CB86 program cannot pick up the character 0 and only picks up the following character.

Is there something I'm overlooking, or is there another way to pick up the use of the cursor keys besides using CB86's `INKEY` function?

Weldon Bailey
Kingwood, TX

You're absolutely right about the way the cursor keys work. IBM picked a two-character code to represent the keys that didn't have good ASCII equivalents, with the first character of the pair being ASCII 0. The second character is a standard ASCII character that, except for the leading null, is indistinguishable from the code produced by some other key.

For example, the cursor keys produce these codes: left arrow = <null> K; right arrow = <null> M; up arrow = <null> H; and down arrow = <null> P. IBM's `INKEY$` *function returns a string that contains none, one, or two characters. If no key was pressed, there will be no characters in the string. An ordinary key will return the single ASCII character that you'd expect. The extended keys (such as cursor or function keys) return two characters, the first of which is always a null.*

Now, I don't know exactly how CB80 and CB86 work, but what you suspect may well be happening. You could try putting the `INKEY` *in a loop, printing out the length of the result as well as the actual characters and their numeric equivalents. That should tell you something.*

One possibility is that CB86 uses a null to represent "no key pressed," in which case you're sunk without a trace. You could write a small assembly-language program that would grab the keyboard interrupt back from BASIC and perform the same function as `INKEY`*, but that's a pretty tricky project.*—Steve

DOS EXEC

Dear Steve:

I have been in the software field for about two years, developing application software in COBOL and BASIC for business purposes. During this time I have often encountered cases where it would be useful to be able to execute DOS commands from within my programs.

I am not an expert in assembly language. Nevertheless, it would be most helpful if you could at least point me in the right direction. Could you also suggest any assembly language books that could help me in developing assembly routines for other purposes?

Floyd D'Aguiar
Bombay, India

A program executes DOS commands from within itself by using the DOS function called EXEC. This function loads and passes control to a specified program. That program can be another copy of the command interpreter (`COMMAND.COM`*), with a command line set up to execute an internal or external command.*

The EXEC function is tricky, and the standard DOS documentation is woefully inadequate. Advanced MS-DOS *by Ray Duncan (Redmond, WA: Microsoft Press, 1986) has a 20-page description of the command, including an example program and a two-page summary with a number of caveats. PC DOS 2.0 and 2.1 had some crippling bugs in the EXEC code, so if you're using either of them, it may be time for an upgrade.*

continued

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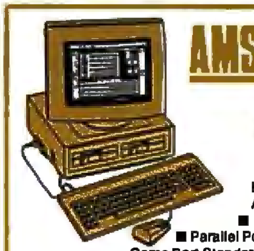

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1987. Delivery boy delivers IBM PS/2™ swiftly and abruptly to the sidewalk. Files saved on 3M data cartridge tape.

ings change, stay the same.

1975. Head of the office trips, pulls plug on HP* 3000. Files saved on 3M data cartridge tape.

1976. Unnamed computer does the unmentionable. Files saved on 3M data cartridge tape.

1977. Office fire bakes Apple* IIs. Files saved on 3M data cartridge tape.

1981. Circuit breaker flips, floppies flop. Files saved on 3M data cartridge tape.

1982. Head crash proves fatal to Lisa.* Files saved on 3M data cartridge tape.

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*True to life stories.

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Circle 2 on Reader Service Card

You'll need to figure out a way to pass control to an assembly routine that will release the excess storage allocated to your COBOL or BASIC program. I'm not sure how to do this with the compilers you're using, but I think it will be a little messy because neither language was intended for this sort of application. Duncan's book details what to do with C and assembler programs, so you may be able to figure out how to use it with your languages.—Steve

Printer Problems

Dear Steve:

The problem I'm having is with a printer interface between a Tandy DMP-2100 (not to be confused with a DMP-2100P) printer and IBM PC XT and AT compatibles. I purchased a cable from Radio Shack that purports to properly connect the Tandy 1200 and IBM PC to designated Radio Shack printers, one of which is the DMP-2100.

When I got everything connected and executed a Shift-Print Screen, I got a perfect screen dump to the printer. Also, when I use WordStar 2000 Plus Release 2.0, which includes a Tandy DMP-2100 printer driver, I get printed output as expected. All this would tend to make me think the cable is functioning.

However, when I type Control-P at the DOS prompt, which should echo the screen output to the printer, I get a message that reads:

```
Write fault error writing device PRN
Abort, Retry, Ignore?
```

Interestingly enough, this message prints out perfectly on the printer. Any ideas?

Eugene W. Hungate
Elkhart, IN

You wouldn't believe the number of letters I get from people who have a printer, a PC, a cable, and no characters on the page. You're ahead of the crowd so far.

Not having your collection of equipment handy, I did a little tinkering around with a PC AT and an ordinary IBM graphics printer. The `Write Fault` *error cropped up when I tried printing something while the printer was set off-line.*

That was the easy part; now comes the deductive logic. I assume, incidentally, that you've made sure that the printer is ready to go, and that you have the cable securely fastened at both ends when you press Control-P. (I make those mistakes, too, by the way.)

If the DMP-1200 is particularly slow, it may be that the print routines give up in disgust. Because DOS, BIOS, and the WordStar driver code can all use different time-out values and retry counts, it's conceivable that everything but the BIOS code works just fine. Take a look at what the printer is doing when the error message occurs. If it's always feeding a line or returning the print head to the left margin, that's a sure sign of a timing problem.

You don't mention which compatible you're using, but if it's a souped-up PC or an AT, the timing problem will be worse. You might want to try a slower machine just to see if the problem will clear up.

You can try changing the BIOS time-out value to a larger number. This would cause all the code that uses the BIOS to wait a little longer before concluding that there's an error. This may or may not help, because I don't know exactly where the error is coming from. Use DEBUG and follow this script:

```
A> DEBUG
-D40:78L1
0040:0078 14
-E40:78 40
-Q
(Return to DOS)
```

The above steps show how to change the time-out value stored at address 0040:0078 from 20 decimal to 64 decimal (numbers given by DEBUG are in hexadecimal). Now try the Control-P trick and see if it works. If so, then the following simple BASIC routine should also fix the problem. Just put the program name into your AUTOEXEC.BAT so that it's run every time you boot your PC, and the problem will be solved.

```
10 DEF SEG &H40
20 POKE &H78,64
30 SYSTEM
```

Store this program in file PRTFIX.BAS and add a line to your AUTOEXEC.BAT file that reads:

```
BASICA PRTFIX
```

I hope this helps, because if it doesn't . . . I'm fresh out of ideas!—Steve

CIRCUIT CELLAR FEEDBACK

Where It's AT

Dear Steve:

I'm interested in building some gadgets to plug into my IBM PC slots. From your last few articles in BYTE, it's obvi-

continued

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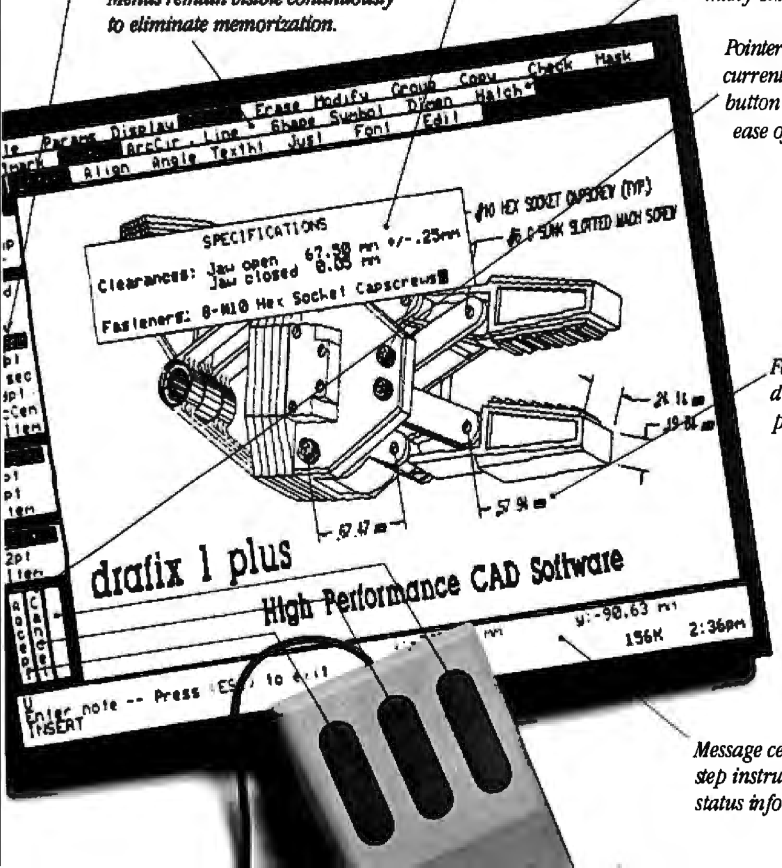

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Circle 99 on Reader Service Card

ous you know how it's done. Is there one book you could recommend that gives the bus transfer protocols between the operating system and those card slots? What do you use for authoritative source documentation? I'm particularly interested in setting up something like a disk controller as a smart-file transfer interface to another system.

Also, I'm really tempted by the low prices on some of the PC AT compatibles. Is there a good source of wisdom on the AT slot-protocol peculiarities?

Any advice that you could give would be greatly appreciated. I know nothing about those slots now, and I'm hoping that I won't have to go through 12 different documents before I find one that gives the information I want. Sampling books here in Berlin is not as easy as browsing in the stores back home.

James L. Barnett
USAFS Berlin, Germany

Actually, the way you find out how the IBM PC bus works is to build something, then figure out why it doesn't work. There are a lot of tricks and "gotchas" that aren't written down anywhere.

Probably the best references are the IBM technical reference manuals for the PC and the AT. While they're short on timing diagrams and explanations, they have the schematics for all the IBM PC adapters so you can see how the logic is put together. IBM tends to use ordinary TTL gates rather than custom logic for the bus decoding and buffering, so you can easily reproduce IBM's logic in your own designs.

I'm not sure how you'd go about ordering these documents from Berlin, but here in the U.S. you can get them from authorized IBM PC stores or by ordering them from

IBM Technical Directory
P.O. Box 2009
Racine, WI 53404-3336

They take checks, money orders, or credit cards (no cash, postal orders, or CODs), and probably require payment in U.S. funds. The manuals you need are

AT Technical Reference, *Part No. 6280070, Form No. S229-9611-00, $105.*

AT Technical Reference Update, *Part No. 6280099, Form No. S229-9608-00, $49.75.*

XT Technical Reference, *Part No. 6290089, Form No. S229-9607-00, $49.75.*

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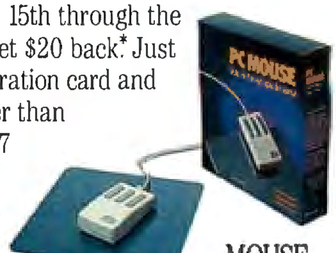

MOUSE SYSTEMS

PCjr Technical Reference, *Part No. 1502293, Form No. S229-9612-00, $35.*

Options & Adapters, *Part No. 6322509, Form No. S229-9612-00, $125.*

EGA Technical Reference, *Part No. 6280131, Form No. SS34-0007-00, $9.95.*

Engineering/Scientific, *Part No. 6280133, Form No. SS34-0009-00, $27.95.*

AT Options & Adapters, *Part No. 6280134, Form No. SS34-0010-00, $9.95.*

The options and adapters technical reference manuals contain the adapter cards. The other volumes contain just system-board and BIOS information. I suggest that you get the XT and AT system reference manuals and the options and adapters volumes for the cards you're interested in. The BIOS listings are particularly useful for figuring out how a program actually uses the hardware.

Some of the prices look like misprints, but they're not. It isn't clear why the original PC Options & Adapters *volume is $125 and the* AT Options & Adapters *volume is $9.95. The* EGA Technical Reference *manual originally cost about $100, and its price has dropped dramatically. Still, you may want to contact the Technical Directory to verify current prices and form numbers.*

Most AT compatibles are very compatible at the bus level—that lesson was learned by the early not-quite-compatibles. The only trick is coping with the higher clock rates: Anything over 8 megahertz tends not to work with some popular expansion cards.

You will need a good oscilloscope if you're serious about this. Sometimes just sitting down, writing a short assembly-language test loop, watching the scope, and sketching what's going on is more rewarding than reading many chapters in some manual. Good luck!—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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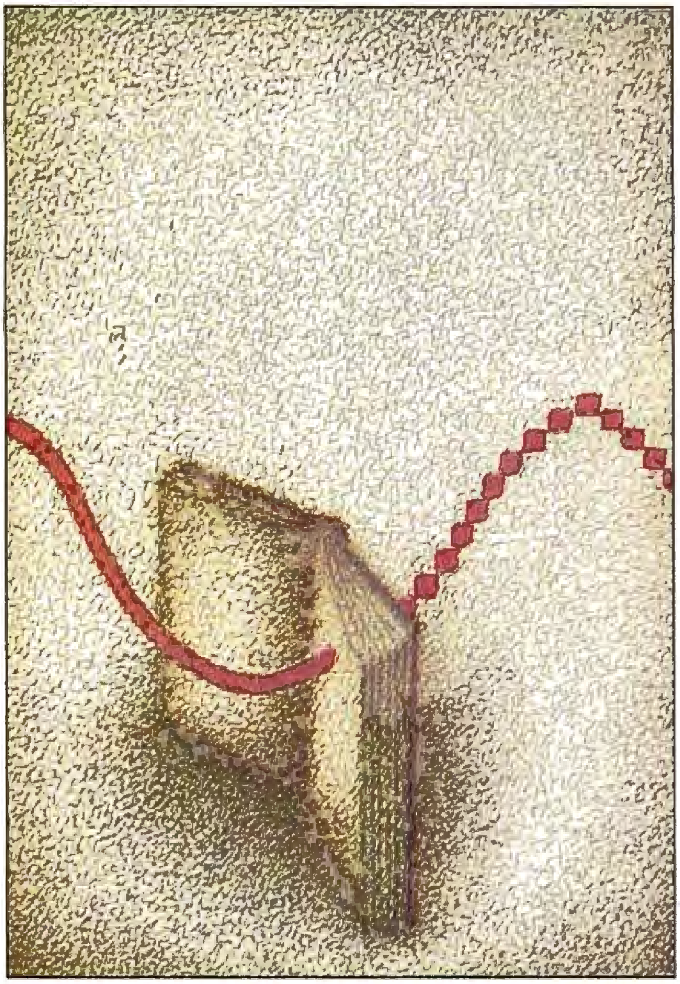

LESSONS IN DIGITAL ESTIMATION THEORY
Reviewed by John V. Olson

Jerry M. Mendel's book is a concise, lucid, and intensely mathematical description of the current state of estimation theory and its extensions. *Lessons in Digital Estimation Theory*, the latest volume in the Prentice-Hall series on signal processing edited by Alan V. Oppenheim, is intended as an introductory text for a one-semester course in estimation theory.

The text is divided into 27 short "lessons," self-contained kernels that express and develop briefly a fundamental idea in estimation theory. Each lesson contains a few problems that are intended to allow the student to flesh out the mathematics and try the techniques presented. The author emphasizes digital implementation of the techniques described, which fits the modern approach to the analysis of signals and systems. Also, as Mendel points out, the mathematics associated with digital estimation theory are simpler than those associated with continuous estimation theory.

Roots of Parameter Estimation

The general task of estimation theory, as practiced in many fields in engineering and science, is to determine one or more of the parameters in a model that describes a physical process. The theory has its roots in Gauss's least-squares approach to the determination of the orbital elements of asteroids from measurements that contain errors. It has continued to be developed—driven, as Mendel points out, by the needs of technology.

The rise of digital technology has seen the concomitant rise in the number and variety of digital algorithms in digital estimation. The field was extended greatly in this century by the work of Wiener and Kalman in developing a least-squares approach to filters. Mendel has chosen to present the techniques of estimation theory in a digital format.

How Mendel Sees It

Mendel views the generalized extensions of the problem of least-squares parameter estimation as a natural extension of digital filter theory. Traditional filter design is concerned with fixed responses to deterministic signals and results in low-pass, band-pass, and high-pass filters that meet certain design criteria in the frequency band. Estimation theory, as Mendel points out, leads naturally to filters that have time-varying parameters.

The Four Steps

To begin the process of parameter estimation, you must perform the most difficult task: the proper description of a model to represent the signal or process at hand. Mendel identifies four steps in the modeling of a physical process: representation, measurement, estimation, and validation. The representation problem involves choosing an appropriate model for a system, here taken to be a mathematical model of the parameters of a system.

Once the system has been modeled, a series of physical quantities must be measured; these can be used to validate the model. It is the task of estimation theory to determine the values of the parameters of the model, including those that cannot be measured directly. Finally, validation of the model is performed using statistical measures of the confidence limits of the estimated model parameters.

Linear to Nonlinear

The bulk of this book deals with the problem of parameter estimation using linear models. In a linear model, the measurements are assumed to have a linear dependence on the parameters of the model and to be contaminated by an additive noise

continued

Illustration by Dave Ridley

field. When the parameters to be estimated can be assembled into a vector that describes the model, then the estimation of the state vector follows naturally from the ideas of parameter estimation.

Mendel provides this unification in a natural way, and it is one of the book's strong points. He ends with several lessons that extend the treatment to nonlinear systems. Most physical systems are described by nonlinear differential equations, and Mendel shows how such equations can be linearized and subjected to the techniques of linear parameter estimation.

A Coherent View

Within this framework, the author examines several important techniques of parameter-estimation theory. By beginning the book with a review of least-squares estimation techniques, he applies them to cases involving both large and small samples. The maximum-likelihood and maximum a posteriori methods are presented along with the best linear unbiased estimator (BLUE). Mendel then moves on to a study of state estimation. He covers the basic state-variable model and includes several examples. Finally, he examines the connection to least-squares theory and discusses the relationship between the Wiener and Kalman filters. Regarding nonlinear problems, Mendel focuses primarily on the treatment of the extended Kalman filter. He concludes with a discussion of the continuous-time Kalman-Bucy filter.

The appendix includes a glossary of major results. This listing lets students trace the logical development of the text, as well as find a particular theorem. Again, it shows the author's effort to bring a coherent view to what have been separate topics in estimation theory.

Classroom Experience

Lessons in Digital Estimation Theory is an excellent book, and I highly recommend it to those who are seeking a first contact with the mathematical foundations of estimation theory. The development of the material begins from a familiar foundation in least-squares theory and moves logically through the modern extensions, always with an eye to their relationship to the original least-squares approach. This well-integrated approach provides a coherent view of the state of estimation theory and its mathematical description.

Mendel states that the book is the outgrowth of a course he has given at the University of Southern California since 1978. The clarity of the ideas presented shows that the book has gone through the tempering process that occurs when a set of ideas is presented frequently in the classroom.

A Welcome Change

Mendel's approach is a welcome change from the current spate of "cookbooks" providing recipes and algorithms. Those may be useful as guides, but the study of the formulation of methods is a more helpful approach. If there is a weakness in *Lessons in Digital Estimation Theory*, it lies in the absence of discussions of the relative strengths and weaknesses of the methods. However, the author includes a few numerical examples for the student, and some of the exercises make use of these examples.

Students using this book must be well-grounded in the mathematics of signal processing. Although the author suggests that the text could be used for self-study, its compact, essentially mathematical presentation makes it more appropriate as a text for a course following a senior-level course in signal processing.

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THE SOCIETY OF MIND

Reviewed by Darrow Kirkpatrick

Marvin Minsky's *The Society of Mind* says more sensible things about how people think than anything else I've read. Minsky has spent years contemplating thinking. He is fascinated by the minds of children, by the simplest and most complex mental problems, and by the challenge of programming computers to think like people. This book is a picture of how his ideas about thinking go together.

Even though the book will be read and studied by those at the cutting edge of psychology and artificial intelligence, Minsky doesn't see his book as scientific scholarship. He wants it to be read as an "adventure story for the imagination." He admits to making hundreds of assumptions and speculations, saying,

> Until we have a more coherent framework for psychology, it will remain too early for the task of weeding out unproved hypotheses or for trying to show that one theory is better than another—since none of our present-day theories seem likely to survive very long in any case. Before we can have an image of the forest of psychology, we'll have to imagine more of its trees and restrain ourselves from simplifying them to death.

The Sum of Small Ideas

The Society of Mind is intentionally unfocused. At the start, Minsky tells the reader that neither thinking nor theories about thinking can be very organized. Evolution has made our minds powerful by using countless, messy cross-connections—and Minsky doesn't quarrel with evolution. He groups his discussions into bite-size sections of one page each, spread across 31 chapters. Fortunately, the excellent glossary and index make the book's tangled web of thoughts easily accessible. Like its subject, the human mind, this book is a society of many small ideas. Minsky believes that when we join enough of these small ideas, we can explain the strangest of mysteries.

The Society of Mind is about psychology, not computer science. Don't read it for explicit directions on how to implement AI on your computer. Those of us in the small-computer world might be disappointed that Minsky barely mentions computer software and hardware, but he does mention AI more and more as the book progresses. I think he wants us to know where many of his ideas were born and where many of them have been tested by experience.

Rereading the Script

Connecting Minsky's ideas with the programming structures and algorithms they grew from is a task left to the reader. I often found myself "reverse-engineering" his conclusions about thinking—back to the computer problems that must have created them.

For example, Minsky says that you learn skills by experimenting to find which agents to use, then preparing a script that will do the job automatically. Later, when you need to solve the same type of problem, you unconsciously play back the script. This sounds like what I do with my favorite macro language when I want to automate a sequence of tedious computer commands. Minsky goes on to say that such a script would be limited if it could work on only one type of thing. Then he describes an "action" script that never refers to the thing it acts on, only to a temporary memory that represents the thing. To me this sounds like the standard structured programming practice of passing generic variables to subroutines.

Throughout the book, Minsky dwells on a few simple

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Northeastern Region: 516-625-0100; Southern Region: 404-948-1346; Midwestern Region: 312-676-5356; Western Region: 714-863-1844 example problems to illustrate his ideas. His Block-Arch and Hand-Change scenario concerns a child playing with blocks and a toy car. The child builds an arch-shaped structure, then notices a strange phenomenon: When you push the car through the arch, your arm gets trapped. Minsky goes on to use this simple situation to explore ideas about how we represent and recognize shapes, how we model space and the relationship of our bodies to it, and how we learn.

You Are Your Agents

Agents are crucial to Minsky's mind society. *Agent* is the term he uses to describe an element of the mind responsible for one thinking function. The majority of agents are just middle-level bureaucrats that manage the activities of agents below them and respond to requests from agents above. You would not be tempted to call the activity of any one agent "intelligent." Yet Minsky believes that when taken together as societies of processes, the mind's agents create emotions, the sense of self, and all the other facets of a human personality. The mind's intelligence emerges from its unintelligent agents.

Memory and Experience

Some of Minsky's most interesting thinking concerns how memory works. Most of us have wondered how the brain stores information. We may have tried picturing a vast reservoir of facts. Yet how could the brain possibly capture reality in a sea of static facts? And how it could retrieve useful information from that sea?

Minsky suggests that the brain does not try to store away facts. It contains special agents he calls *K-lines*, which can make records of what some agents are doing at a certain moment. Later, if you activate those K-lines, they restore those agents to their previous states. Thus, K-lines take a partial "snapshot" of your brain state during a certain event. You remember previous mental events because parts of your brain are doing precisely what they did before, and other parts are reacting to those parts as though the same events are happening again.

How does the mind know to arouse so many appropriate memories so quickly, without arousing too many? According to Minsky, when we learn by attaching agents to K-lines, we don't attach them all with equal firmness—we make strong connections only at a certain level of detail, or "level band." Weaker connections at higher and lower levels are default assumptions that retreat when other agents challenge them. These default assumptions contain some of our most valuable commonsense knowledge: They tell us what is usual or typical.

Minsky says that older psychological theories are based on pieces of memory too small or too large to be practical. He proposes a compromise that has been effective in AI work: structures called *frames*, which represent what we've acquired from previous experience. We remember millions of stereotypical frames that represent everyday happenings, such as being in a certain kind of room. A frame is like a blank form with many empty boxes, called *terminals*, to be filled. To represent a specific situation, we fill in the terminals with more detail. Normally, terminals come with agents already attached, and these are the default assignments that make up level bands.

To explain his theory, Minsky invents an intimidating medley of terms. For example, a *polyneme* is a type of K-line that arouses different activities in different agencies by sending the same message to each. *Micronemes* are inner mental-context clues that shade the mind's activities. Pronoun-like devices called *pronomes* access whatever mental activities are in progress. Pronomes that can operate in several different realms at once are *paranomes*. An *isonome*, a sort of opposite to a polyneme, is an agent that has a uniform effect on different agencies.

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A Fresh Start

Minsky's ideas seem very close to the truth about how minds work. This makes them seem obvious, because on a superficial level we are all familiar with how the mind appears to work. However, the theoretical basis for these practical ideas is far from obvious.

For me, Minsky has made a fresh start on explaining the mind. His book doesn't take the little we know about brain hardware and try to force-fit a theory of mind onto the world of neurons, synapses, and brain chemistry. Instead, the book is a lively discussion of the brain's software. It takes cues from biology, child psychology, and computer science to build a model of how a thinking machine as powerful as the human brain might work.

Minsky says frightening things that may threaten our sense of self and our place in the universe. But he also has words of encouragement. He doesn't accept incompetence of intellect as a normal, if unfortunate, deficiency in talent. He thinks that intellectual incompetence should be treated as an illness to be cured, just as emotional and other human deficiencies are treated.

"Only" a Machine

For Minsky, the mind is a machine—a powerful, complex machine, but nevertheless a machine we can understand using scientific methods. He wonders why people are so distraught that our most prized possession, the mind, might be "only" a machine. For Minsky, machines are the most wonderful constructs on earth:

> Are minds machines? Of that, I've raised no doubt at all but have only asked, what kind of machines? And though most people still consider it degrading to be regarded as machines, I hope this book will make them entertain, instead, the thought of how wonderful it is to be machines with such marvelous powers.

Darrow Kirkpatrick (P.O. Box 376, Rosendale, NY 12472) is an engineer, consultant, and freelance technical writer.

THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE: LISTENING FOR LIFE IN THE COSMOS

Reviewed by Jack Kirwan

Philosophers from every culture wonder about the possibility of other life forms in the universe. But because there has been absolutely no data and no way of getting it, the possibility has never become more than idle speculation.

Thanks in large part to computers, all that is changing. Not only have the arguments for and against extraterrestrials become more sophisticated, so have the techniques of sending information. Addressing this topic is Thomas R. McDonough's interesting, very clear, but sometimes uneven survey, *The Search for Extraterrestrial Intelligence*.

McDonough, a lecturer at California Institute of Technology, is the coordinator for the Search for Extraterrestrial Intelligence (SETI) within the Planetary Society, so he brings to the book a definitive pro-SETI bias. This is not so bad, except for his chapter on the objections to SETI (which I'll discuss later). Unlike Edward Regis Jr.'s excellent anthology, *Extraterrestrials—Science and Alien Intelligence* (see my review in the August 1985 BYTE, page 62), McDonough's book is not an academic, highly technical treatment of the subject. It is popularly written, and, as Isaac Asimov and Ben Bova have demonstrated, popular writing is not necessarily unscientific. However, McDonough wants extraterrestrials to exist so much you can almost taste it.

continued

SETI's Earliest Beginnings

Despite centuries of philosophical and theological speculation, serious searching for extraterrestrial intelligence began in the 19th century. In the 1820s, mathematician Carl Friedrich Gauss proposed talking to lunar inhabitants by planting pine trees "in the shape of squares on the side of a right triangle." He hoped this would communicate to the extraterrestrials on the Moon that humans at least knew the Pythagorean theorem. Nothing came of this, nor of the Viennese astronomer Joseph von Littrow's idea of digging a 20-mile ditch in the Sahara, filling it with kerosene, and tossing in a lit match.

Mostly due to the American astronomer Percival Lowell, interest shifted from the Moon to Mars. Lowell was convinced (thanks to the work of Italian astronomer Giovanni Schiaparelli) that there was intelligent life on Mars. He wrote a series of scholarly books on the subject. In fact, as McDonough points out, the Martian extraterrestrial hypothesis became so widely accepted that "a contest was eventually held to reward the first discovery of intelligent life beyond Earth, excluding Mars—because that would be too easy."

Most of the confusion about Mars resulted from a simple mistranslation. When observing Mars, Schiaparelli had seen what appeared to be grooves or straight lines through his telescope. He labeled them "canali," the Italian word for channel. In the excitement, a linguistic jump mistranslated the word as "canal," thus implying a level of intelligent engineering.

The Modern SETI

The modern SETI began in 1959 with an article by Philip Morrison and Giuseppe Cocconi in the British journal *Nature*. Discounting the idea of other intelligent life in the solar system, they concluded that "the easiest way to communicate across the galaxy would be by radio signals." And with this, the story of SETI begins to pick up.

The first problem, of course, is which of many channels to tune into. Trying to cover all parts of the sky with every channel is a centuries-long, mind-boggling concept, so Morrison and Cocconi proposed using the fundamental radio signal that hydrogen atoms broadcast.

In McDonough's words, "over the vastness of space there are so many atoms that the feeble radio broadcasts of each one would add up to a detectable signal. The atoms broadcast at a frequency of 1420 megahertz." Morrison and Cocconi reasoned that if there are other civilizations in the universe, they would probably know about this hydrogen signal, so 1420 MHz would be the channel of choice.

Herein lies another major problem with SETI: trying to figure out what the members of a totally alien civilization would be like. Some simplistic judgments assume that extraterrestrials would follow certain positive terrestrial philosophical bents—often those of the assumers. Others think that any advanced civilization anywhere must share certain scientific basics (e.g., the speed of light and pi) and must go on from there to develop means of communication. But for the most part, putting together an intelligent and rational SETI package is a complicated and interesting tale, and the strongest part of McDonough's book.

The Drake Equation

Naturally, the biggest question in SETI is whether or not anybody is out there sending or receiving. Here we get an interesting professional breakdown. A lot of astronomers tend to be on the pro-extraterrestrial side, while many microbiologists are opposed. SETI pioneer Frank Drake, for example, set up seven questions (to form what's now labeled The Drake Equation) to argue for the defense. These questions (plus McDonough's estimated answers in parentheses) are as follows:

continued

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1. How many stars are in the Milky Way galaxy? (About 400 billion.)
2. How many of these stars have planets? (Around 40 billion.)
3. How many of these planets are suitable for life? (Estimating 10 planets per star: 40 billion.)
4. How many of the nice planets actually develop life? (For the sake of argument, 1 in 10: 4 billion.)
5. How many of these develop intelligent life? (Let's say one in a hundred with life evolves intelligence: 40 million.)
6. How many of these develop civilizations with technology capable of interstellar communication? (If even one civilization in 10 does this, there might be 4 million.)
7. How long do these civilizations last? Here McDonough does some fancy footwork. (The Earth is 5 billion years old, and the age of the universe is about 15 billion years. Suppose a civilization is communicative for a thousandth of the age of its home world—10 million years. That would mean that one-thousandth of the 4 million technological civilizations—some 4000 worlds—could be out there right now.) This all boils down to the Drake Equation: ($N = N_* f_p n_e f_l f_i f_c f_L$).

Level of Speculation

But how accurate is this intellectually stimulating model? Every one of McDonough's answers is qualified with "mights" or "supposes" or "estimates." Once we get past the first question, the slide into speculation becomes steep pretty fast. But at least it's a try.

Unlike Drake and the astronomers, the microbiologists argue from the little to the big. In a nutshell, their argument is that of all the millions of species that came into being on earth, only one (Homo sapiens) developed what could really be called intelligence. And of all the dozens and dozens of human cultures, only one (the rational, scientific subculture of Western man) developed a technology able to send and receive interstellar communication. Furthermore, all this took place only in the last 150 years. So, looking at the question from a totally biological point of view, the microbiologist makes a pretty good case for SETI's stand not being viable.

As a matter of fact, the biggest weakness in *The Search for Extraterrestrial Intelligence* is that McDonough devotes only one chapter to "Scientists Against SETI." Granted, this is an advocacy book written by an unabashed (but rational) enthusiast, but there are legitimate arguments against SETI (mathematician Frank Tipler's 1980 essay "Extraterrestrial Beings Do Not Exist" in particular), and they deserve more than the few pages McDonough offers up.

New Ideas

The final chapter of *The Search for Extraterrestrial Intelligence*, "The Future," is ostensibly about "what will happen if SETI is successful." Here, McDonough tosses out a lot of speculation and some tight ideas about culture shock—not from extraterrestrials but about what is happening on earth right now. For instance, due to satellite communications, people in Belize who never saw a baseball glove or bat have become Chicago Cubs fans. As McDonough says, "The citizens will never be the same; they have absorbed an alien culture." Some people bemoan the fact that primitive cultures are being contaminated by external influences, and some—mostly in the "primitive" cultures—think it's just dandy.

In the last analysis, the real value of this book is not that aliens may or may not be out there listening and broadcasting, but rather that such thinking and speculation generates new ideas. The door to possibility should never be latched. ■

Jack Kirwan (Department of Economics, University of Arizona, Tucson, AZ 85721) is assistant editor of The Energy Journal.

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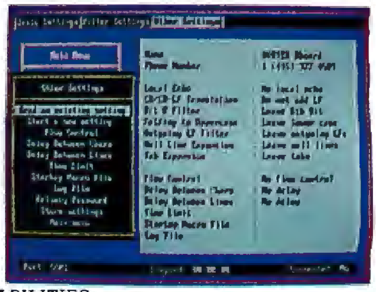

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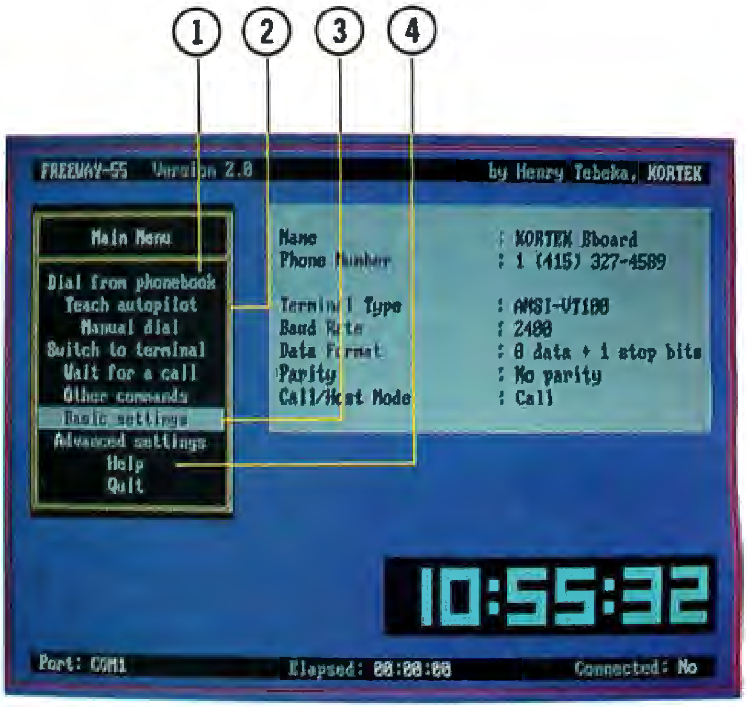

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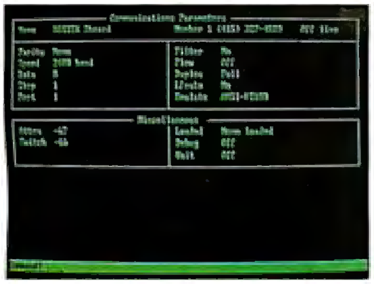

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Xtalk XVI	NO	NO	NO	NO	NO	NO	NO	YES	110-115.2k	WELL. . .	$195.00
Xtalk Mk.4	YES	NO	NO	YES	YES	YES	YES	YES	300-115.2k	WELL. . .	$245.00
Smartcom II	NO	NO	YES	LIMITED	LIMITED	NO	NO	NO	110-9600	NO	$149.00
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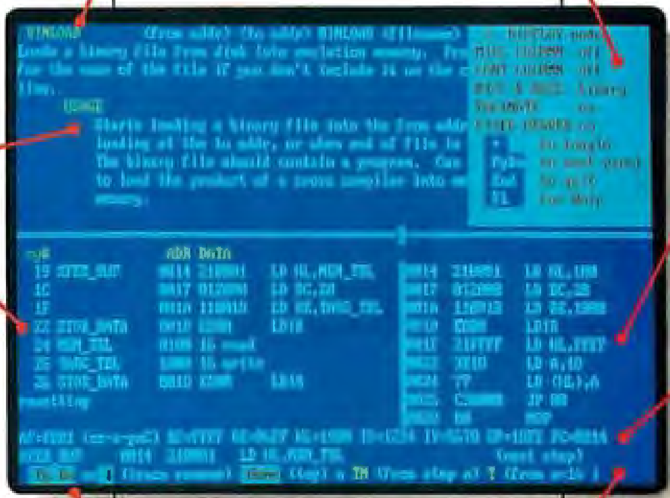

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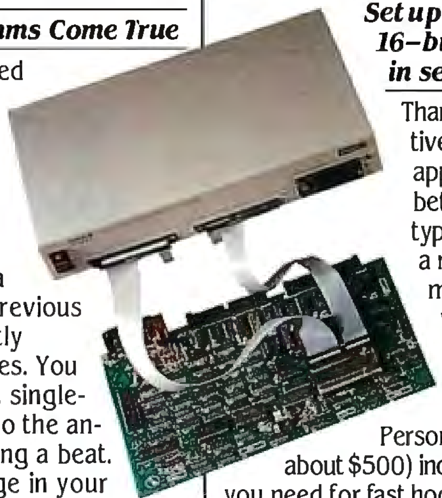

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Features

Special BIX supplement:
In "Apple II Memory Management" (found in the oct.sup conference on BIX), Howard Huang explains how to break the 64K-byte memory barrier on your Apple II programs, and presents Ultra Copy, a disk-duplicator program that employs the added RAM. For information on joining BIX, see page 267.

Rich Malloy, G. Michael Vose, and George A. Stewart

The Tandy Anniversary Product Explosion

Four new computers from the maker of the TRS-80 Model I

Ten years is a very long time in the microcomputer business. Having passed our own tenth anniversary over two years ago, we can proudly assert that this event is a notable accomplishment. Only a few microcomputer-related manufacturers have been in business that long, and fewer still have survived the myriad changes that have rocked the industry during that time. What better way to celebrate such a milestone than by introducing a complete new line of products?

Tandy did exactly that in its tenth anniversary celebration in August. The Texas-based company came out with four new computers and a laser printer. More importantly, the company says it will continue to make most of its previous products available. All told, Tandy might now be offering the most extensive line of computer products in the world (see the text box entitled "Tandy's Lineup" on the opposite page).

The four new computers are the Tandy 4000, a low-priced 80386-based computer; the Tandy 1400 LT, an IBM PC XT-compatible laptop portable; the Tandy 1000 TX, a low-priced 80286 system; and the Tandy 1000 HX, a new low-end system for home and schools. The company also introduced the LP-1000, its first laser printer.

The information for this article was gathered this past summer; we have tested early versions of each machine. If any details change by the time this article runs, we will update you as soon as possible.

Photo 1: *The Tandy 4000, an 80386-based machine.*

The Tandy 4000

Practically every company that produces MS-DOS computers seems to have come out with a computer based on Intel's 80386 microprocessor, and Tandy is no exception. The new Tandy 4000 (see photo 1) does not seem to scale any technological peaks, but, like the earlier Tandy 3000, it appears to be a good solid office workhorse. Perhaps the most significant feature of the 4000 is its price: $2599 (without a monitor or hard disk drive). This is less than many IBM PC AT-compatible systems that perform only a half to a third as fast.

It is also interesting to note that in less than a year, the price of 80386 systems has dropped by a third: from $6499 for the Compaq Deskpro 386 last September to the new Tandy 4000 ($4299 with monitor and 40-megabyte hard disk drive).

External

The Tandy 4000 comes in practically the same box as the older 3000. It measures 19 by 18 by 6½ inches. Unlike the 3000, however, it features a keylock on the front panel, and on the right side of the front panel there is room for three half-height disk drives instead of just two. Like the IBM PS/2 Model 80, the 4000 includes in

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its standard configuration a 1.44-megabyte 3½-inch floppy disk drive. Tandy happily points out that other types of disk drives—such as a 5¼-inch floppy—are available as options. The keyboard departs from the XT style used by the 3000 and looks very similar to the latest PC AT keyboard, complete with 12 function keys arranged horizontally, and LED indicators.

Internals

Like most 80386-based systems, the model 4000 uses a 16-megahertz 80386 processor. Tandy has employed an 80386 chip set from Chips and Technologies, and makes use of eight custom ASIC (application-specific integrated circuit) chips. A socket exists for an 8-MHz 80287 math coprocessor, with 10-MHz 80287 support slated for "the near future." Also slated for the future: Tandy will offer a new version of the 4000 that will support the Intel 80387 coprocessor.

As for memory, the 4000 can currently accommodate up to 4 megabytes. Half of this will reside on the motherboard, and the other half on a proprietary 32-bit-wide memory card. At some point in the future, when 1-megabit RAM chips become more available, the 4000's memory can be boosted to 16 megabytes.

The 4000's memory is stored on SIMMs (single in-line memory modules). Each SIMM holds nine 256K-bit chips for a total of 256K bytes of memory plus parity on each SIMM. The system uses fairly fast 100-nanosecond memory chips. The motherboard has eight SIMM sockets. When you buy the machine, four of these sockets are already filled, giving a base configuration of 1 megabyte of memory. To bring the memory up to 2 megabytes, you simply insert four more 256K-byte SIMMs, at a cost of $599. You can add another 2 megabytes using the memory-expansion board. When 1-megabit chips—and thus 1-megabyte SIMMs—become available, you can replace the eight SIMMs on the motherboard with eight 1-megabyte SIMMs, to get 8 megabytes on the motherboard.

Memory can then be further expanded by performing this same operation on the memory-expansion board, increasing the total system capacity to 16 megabytes.

The amount of memory present has an effect on the system's speed. The memory controller in the Tandy 4000 uses a page-interleaving scheme when two or four additional SIMMs are installed. The page-interleaved design allows overlapping of row and column address strobes. This overlap permits access to a memory location by changing only the column address strobe. This operation will be successful 50 percent of the time. The other 50 percent requires both a row and a column address strobe.

A Tandy 4000 with 2 megabytes of RAM is organized into 1024 pages, each containing 2K bytes with the same row address. The 2K-byte pages are arranged into two banks, with the odd-numbered pages in one bank and the even pages in the other. Two conditions allow zero-wait-state operation using this page-interleaved scheme: a subsequent memory access in the current 2K-byte page or a subsequent access in the other bank.

The page-interleaving memory controller results in a performance improve-

continued

Tandy's Lineup

Although Tandy is sometimes overlooked as a major computer company, the Texas-based retailer offers the widest selection of computers and accessories of any manufacturer in the U.S., and perhaps in the world. Here is a list of its current offerings, including the recently announced products:

Computer	Processor	Operating System	Price
Tandy 6000	68000	Xenix multiuser	$3499
Tandy 4000	80386	IBM AT compatible	$2599
Tandy 3000	80286	IBM AT compatible	$2199
Tandy 3000 HL	80286	IBM AT compatible	$1699
Tandy 2000	80186	MS-DOS	$1599
Tandy 1400 LT	NEC V-20	IBM XT-compatible laptop	$1599
Tandy 1000 TX	80286	IBM AT compatible	$1199
Model 4D	Z-80A	CP/M, TRSDOS	$1199
Tandy 1000 SX	8088	IBM XT compatible	$ 999
Tandy 1000 HX	8088	IBM XT compatible	$ 699
Tandy 1000 EX	8088	IBM XT compatible	$ 599
Tandy 200	80C85	Laptop	$ 799
Tandy 102	80C85	Laptop	$ 499
Color Computer 3	68B09E	OS-9	$ 219
Color Computer 2	6809E	OS-9	$ 99

Printer	Type	Main feature	Price
LP-1000	Laser	300 dpi	$2199
DMP 2200	Dot-matrix	380 cps	$1295
DMP 2110	Dot-matrix	24-wire printhead	$1295
DWP 520	Daisy-wheel	43 cps	$ 995
DMP 430	Dot-matrix	18-wire printhead	$ 699
DMP 130	Dot-matrix	100 cps	$ 699
DWP 230	Daisy-wheel	20 cps	$ 399
DMP 105	Dot-matrix	57 cps	$ 199

Tandy also offers a line of pocket computers, modems, and monitors, and even a plotter.

ment, although in our tests it was barely noticeable.

In addition to the proprietary 32-bit memory-expansion slot, the system has 6 IBM PC AT-style slots, and two PC XT slots. On the back panel of the system is a serial port and a parallel printer port.

Performance

Using our simple Multiplan recalculation test, we found that the 4000 was about 6.9 times faster than an IBM PC (1.53 seconds on the 4000, 10.5 seconds on the PC). In our other benchmark tests aimed specifically at the 80386 processor, the 4000 seemed to be just slightly slower than the Compaq Deskpro 386, the IBM PS/2 Model 80, and the PC's Limited 386. With 2941 Dhrystones per second, the difference was in the range of approximately 12 percent to 14 percent (the Compaq Deskpro 386 delivers 3748 Dhrystones per second, and the PCs Limited 386 yields 3846). The Sieve test showed the Tandy 4000 taking 6.07 seconds, the Compaq 5.99 seconds, and the PC's Limited 386 5.15 seconds.

Software

Like most other Tandy computers, the Phoenix BIOS-based Tandy 4000 comes with MS-DOS and BASIC included. The system also comes with three utilities: a caching utility (which now seems to be standard on high-performance computers), an expanded-memory manager that allows certain applications to make use of the memory above 640K, and a monitor program that Tandy says will allow you to have up to nine different sessions available at the same time. The user can easily switch from one session to another, but the sessions do not execute simultaneously.

Flaws

One thing we did not like about the 4000 was a report that it would pass the FCC Class A certification, but not the stricter Class B test. This means that the device causes too much electromagnetic radiation for use in most homes. Such radiation is common for 80386-based systems because of their high clock speeds. But, all in all, the 4000 looks like a solid office machine for a very reasonable price. If it performs as well as the 3000 has, then it is a very good buy, indeed.

The Tandy 1400 LT

Tandy practically invented the laptop computer, but until recently it has lacked an IBM PC compatible. The Tandy 1400 LT (see photo 2) fills that gap, and, though it has no revolutionary features, it does have all the required ones—at a very competitive price. The only disadvantage might be that, in view of its weight, it might have too many features.

Like the Tandy 100, the new 1400 LT is manufactured in Japan. Because it uses an 8-/16-bit processor, it should not, however, be affected by this year's tariff restrictions. Also, because Tandy deals with its manufacturers only in terms of dollars, the computer's low price—$1599—should remain constant despite fluctuations in the yen. At least one other company has had to raise the price of its portable because of this.

Appearance

Externally, the new machine looks a great deal like IBM's PC Convertible, including the rather significant front-to-back length. But while IBM placed several important features on option modules, the Tandy machine includes almost all the features of a desktop system as standard. The 1400 LT measures 14.5 by 12.4 by 3.5 inches, about the same size as the Convertible. It weighs 13½ pounds, a little heavy for laptops. The machine uses the familiar "clamshell" design, with a display that folds over the keyboard for travel. Immediately behind the keyboard are two 3½-inch 720K-byte floppy disk drives. On the right side of the machine are an on/off switch and a contrast control for the screen. The back panel contains a parallel port, both an RGB and a composite monitor connector, a 9-pin serial port, an external disk drive connector, and an external keyboard connector. Also on the back is an external bus connector and a small slot for an internal modem. Under the keyboard is a handle that slides forward for easy carrying.

Display

The 1400 LT has a fairly high-contrast, dark-blue-on-light-blue liquid-crystal display that makes use of supertwisted liquid crystals and electroluminescent backlighting. It looks very much like the Zenith Z-181 display, but it has a flatter aspect ratio. Like most computer LCD screens, the 1400 LT's screen can display 80 by 25 lines and has a graphics resolution of 640 by 200 pixels. However, unlike some other LCDs, the 1400 LT's screen can also display eight shades of gray (blue, actually). These multiple levels of shading are achieved by refreshing the pixels at varying intervals of time. As a result, pixels displaying the lightest shades, which are refreshed only a small number of times a second, appear to flicker. On the machine we saw, which was a preproduction model, this flicker was quite noticeable for one or two of the lighter shades; since the background was a light shade, the entire screen flickered. But the company says that on production machines, it should be less noticeable.

To save battery power, the backlighting can be turned off. Surprisingly, even with this feature turned off, the screen still has an impressive amount of contrast. The display can be adjusted to any angle and can even be placed down flat on its back against the machine if you want to use a CRT monitor instead. The display is also removable, although Tandy did not imply any future upgrade capability.

Keyboard

The 1400 LT has a fairly well-populated keyboard for its size. Its 76 keys include 12 function keys arranged horizontally

Photo 2: *The Tandy 1400 LT laptop, a portable computer weighing 13½ pounds.*

along the top, and an inverted-T cursor key arrangement in the bottom right. The keyboard is more like the Tandy 1000's than the IBM AT's. One possible problem is that, because of the front-to-back length of the computer, it may be uncomfortable for some people to use on their laps, as the keyboard may be uncomfortably close to the abdomen. This is a problem on many of the new so-called laptops.

The only things that seem to be missing from the insides of the 1400 LT are an 80286 processor and a complete AT-style expansion bus. Everything else is already there: an NEC V-20 (compatible with the Intel 8088) running at 7.14/4.77 MHz, 768K bytes of memory (128K of which is used as a RAM disk), two 3½-inch 720K-byte floppy disks, a socket for an 8087 math coprocessor, a CGA, and a real-time clock/calendar, which the company says is missing from most other laptops.

A nice feature of the RAM disk is that its contents remain intact even if the user performs a "soft reset" of the system. Tandy claims that the NEC V-20 is 10 percent to 15 percent faster than an equivalent 8088. We did a test using Microsoft's Multiplan to verify this. The test, a simple recalculation, ran about 62 percent faster on the 1400 LT's fast-speed mode (7.14 MHz) than on an IBM PC (4.77 MHz). We had expected only a 50 percent speedup due to the difference in clock speeds.

The 1400 LT uses a removable nickel-cadmium battery pack that is about the size and weight of eight C batteries. This battery pack powers the machine for about 4 hours, depending on disk usage. It can be recharged overnight, or with an AC adapter, while the 1400 LT is being used. A complete recharge takes 16 hours. For those situations requiring longer operation, a second battery pack ($79) can replace a worn-down unit. The AC power supply weighs about a pound.

Tandy claims that the 1400 LT is the closest you can get to an open architecture on a laptop. For those who would like to add a special device to the computer, an expansion port on the back of the machine accesses all the expansion bus lines. Though Tandy is not currently offering an expansion box for the 1400 LT, the company says it will provide documentation to anyone who wants to build such a device.

Those who want to attach an alternate graphics board will be relieved to hear that the company says the internal graphics adapter can be disabled. Besides an 8087, the only internal enhancement offered by Tandy is an internal 300-/1200-bit-per-second Hayes-compatible modem. This modem sells for the very competitive price of $200.

Interfaces

When it comes to interfacing capabilities, the new Tandy laptop appears to concede nothing to the low-end desktop machines. Of course, it has a serial and a parallel port. It also has both an RGB connector and a composite monitor connector, for those who prefer to see their work in color. There is even a keyboard connector, by which you can attach any of Tandy's full-size keyboards.

The big question for any 3½-inch-drive machine is: How do you connect a 5¼-inch drive to it? Tandy uses a straightforward approach to this by supplying an external disk drive connector on the back of the machine. The problem is that Tandy is not currently offering such a drive. Instead, the company suggests that users install 3½-inch drives on their desktop Tandy machines and do the conversion there, or use Traveling Soft-

continued

ware's LapLink to transfer files from the 5¼-inch desktop to the 3½-inch laptop.

Although the company does not offer a 5¼-inch drive, it did demonstrate how easily you could add one. Apparently, all you have to do is attach a power supply and the appropriate connector to the external 5¼-inch drive that Tandy sells for its Model 1000 EX. Tandy suggests that a third-party company might offer one. Note that if you were able to add an external drive, there is a switch to allow that drive to be the default boot-up drive.

Software

Unlike the Tandy Model 1000, the 1400 LT does not come standard with Tandy's DeskMate software package. The company said, however, that such bundling might occur in the future. Both MS-DOS and GWBASIC are included in the system's base price. The 1400 LT also has an interesting setup facility that allows you to set various parameters such as processor speed and the default video device.

Perhaps the only thing we don't like about the 1400 LT is its weight. It is about 1 to 3 pounds heavier than similar machines, such as the Zenith Z-181, the NEC MultiSpeed, and the Toshiba T1100 Plus. Tandy claims that one advantage of the size is that Tandy can easily add a hard disk without a major redesign. The company, however, again made it clear that it was not offering such an option at this time.

The Tandy 1400 LT seems to have all the essentials and appears to outclass all its competitors in terms of features. We applaud Tandy for not skimping on any of the necessities for the sake of a low price.

Tandy 1000 TX

Performance is the watchword of Tandy's new 1000 TX (see photo 3). The $1199 machine is based on an 80286 microprocessor running at 8 MHz (switchable to 4 MHz) with one wait state. A preliminary "working sample" of the computer equipped with an optional 80287 floating-point coprocessor ran BYTE's benchmarks at roughly the same speed as an IBM PC AT (see table 1).

The 1000 TX does not provide an AT bus architecture. As one Tandy engineer put it, the 1000 TX is "an 80286 in an IBM PC XT architecture." The most immediate implication is that all the expansion slots on the machine are for IBM PC XT–style expansion cards. The 1000 TX cannot accommodate cards designed specifically for the AT bus. Another more long-range implication is that the machine will not run OS/2.

The machine comes with 640K bytes of 150-ns RAM and a 3½-inch, 720K-byte floppy disk drive. Beyond that, it closely resembles the 1000 SX. It has a separate keyboard and system unit.

The system unit has space for a 5¼-inch device, which could be any of the following: a 20- or 40-megabyte 5¼-inch hard disk drive, or a 5¼-inch floppy disk drive, a second 3½-inch floppy disk drive, or a tape backup. A CGA, parallel and serial ports, two joystick adapters, three-voice sound, speaker, and headphone jack with volume control are all standard. The motherboard has a socket for an 80287 floating-point coprocessor, which Tandy sells for $399.95.

The system also includes Personal DeskMate 2 and MS-DOS 3.2 with GWBASIC. For a display, Tandy recommends its CM-11 RGB-intensity (RGBI) monitor ($399.95), bringing the system cost to about $1600.

Photo 3: *The Tandy 1000 TX, an 80286-based version of the company's top seller.*

Expansion

The TX allows for memory expansion to 768K bytes, of which 128K bytes are dedicated video RAM. With this addition, Tandy claims video operations are about 10 percent faster, and the user ends up with more usable RAM in the original 640K bytes. This option costs $49.95.

The 1000 TX has five expansion slots capable of accommodating IBM PC XT cards up to 10 inches long. It has no slots for AT-style cards. The technical reason is that the TX's I/O bus has only 8 data lines. AT-style cards use 16 separate data lines.

The TX would not make a practical host machine for OS/2 because its memory space is limited to 640K bytes of RAM. Additional RAM would have to be connected through the 8-bit data paths.

Of course, Tandy didn't design the machine for the OS/2 market; the TX is supposed to be a high-performance IBM PC XT–compatible suitable for workstation use, home, office, education, and small business. (The workstation angle is based on the unit's low cost and the idea that workstations rely on file servers for storage rather than on local devices.)

Performance

We ran four computational benchmarks on a TX equipped with an 80287 floating-point coprocessor, and the results show that the machine is indeed a class above the PC and XT computers. We weren't able to test disk access, but a Tandy spokesperson said I/O times were likely to be in line with XT performance, despite the presence of the 80286.

Tandy 1000 HX

It takes more than a low price to make a home computer, and Tandy has recognized this in its new 1000 HX machine (see photo 4). The $699 machine comes with a number of significant user-friendly features: MS-DOS 2.11 in ROM; a menu alternative to the A> prompt, also in ROM; a nonvolatile storage device for storing the user's system configuration; and an enhanced, ROM-based version of the company's integrated software system, Personal DeskMate 2.

Having MS-DOS in ROM means that it takes less than 3 seconds to power up. The arrangement also makes a one-disk system more convenient to use: Upon ending a disk-based application, it isn't necessary to remove the application disk and insert a disk containing COMMAND.COM, as happens when some applications are used in a one-drive system without MS-DOS in ROM. A one-drive HX system is also practical in terms of storage capacity, since the built-in drive is a 3½-inch 720K-byte device. The unit has space available for installation of another 3½-inch drive ($169.95).

Beyond these changes, the HX closely resembles the 1000 EX that Tandy introduced in August 1986: an integrated keyboard and system unit with an 8088-2 microprocessor running at 7.16 MHz or 4.77 MHz, 256K bytes of 150-ns RAM expandable to 640K bytes, an on-board CGA, a parallel printer interface, a connector for an external 5¼-inch disk drive, and an expansion slot for one of Tandy's "Plus" circuit boards. There is no socket for an 8087 floating-point coprocessor. The rear-panel disk and printer ports are printed-circuit card edges rather than the DB plugs found on most personal computers.

The MS-DOS utilities, Personal DeskMate 2 modules, and GWBASIC are included on a 3½-inch floppy disk. A monitor is not included; Tandy recommends its CM-5 RGBI monitor, which sells for $299.95 and makes a total system price of just under $1000.

MS-DOS in ROM

According to John Patterson, senior vice president of Tandy Computers, the choice of which MS-DOS version to put in ROM was obvious. Software reliability is the primary concern, and version 2.11 has been in use for several years without having any major problems discovered.

Size is another consideration; MS-DOS versions 3.0 and higher require about 18K bytes more RAM than 2.11 requires. (MS-DOS loads and executes in RAM, regardless of whether it is stored on disk or in ROM.)

The HX actually carries 128K bytes of ROM; half of that is devoted to the Phoenix IBM compatibility BIOS version 2.51 and MS-DOS 2.11 invisible files MSDOS.SYS, IO.SYS, and COMMAND.COM. The other 64K bytes of ROM contain the HX menu program and the core routines for Personal DeskMate 2. Patterson said Tandy was considering offering some support to software developers who want to use the PDM2 ROM routines to speed and simplify the development of applications for the HX.

Nonvolatile Memory

Even though the HX comes with MS-DOS 2.11, you can use other versions by booting the computer from the 3½-inch drive or even from an optional external drive. A 16- by 16-bit EEPROM device stores the primary boot device and other information commonly specified in the CONFIG.SYS and AUTOEXEC.BAT files, including the microprocessor clock speed selection, the graphics mode, and whether to run the menu program automatically or go to the command level on boot-up.

To change the EEPROM settings, you run a setup program included on the MS-DOS utility disk.

The Menu Program

The ROM-based menu program provides a way of executing application programs without having to type `DIR` to see the directory and then type the name of the program file you want. Instead, a window shows all the `.EXE` and `.COM` files in drive A: (the internal drive). You select a program by moving the cursor to it and pressing Enter.

Function keys in the menu program allow you to activate Personal DeskMate 2, change the date and time, see the current directory in drive A:, and reboot the system from drive A:. Pressing Escape returns you to the MS-DOS `A>` prompt.

In short, the menu program provides you with quick access to the most commonly used operations without requiring you to type in any commands.

One minor deficiency of the menu program is that it does not support subdirectories; the directory window shows only those program files in the currently selected subdirectory or the root directory. To change directories, you must revert to the standard MS-DOS command level.

Personal DeskMate 2

Personal DeskMate is a graphics-oriented environment for running productivity and other software, including a calculator, notepad, calendar, phone directory, text, worksheet, and telecomm. Music is a new addition that lets you compose three-voice music in standard musical notation. Paint now offers 16 colors at once with 320- by 200-pixel resolution.

Personal DeskMate 2 includes support for an optional joystick or mouse. The HX has two joystick ports built in, and Tandy sells a $29.95 joystick that performs the pointing function reasonably well when it is set to the "free-floating" mode.

Expansion

The HX has only one expansion slot. To add more than one card, you must plug the optional memory-expansion card ($129.95) into the on-board slot. The expansion card brings the total system memory up to 512K bytes and gives two additional slots for other Plus cards. The expansion card also includes a DMA (direct memory access) chip for faster block transfers between memory and external devices.

A serial interface and a clock/calendar circuit are omitted from the basic machine. Tandy has a neat solution to the latter: an IC-size assembly that plugs into

continued

Photo 4: *The Tandy 1000 HX, an 8088-based machine with MS-DOS in ROM.*

an IC socket on the motherboard. The $39.95 option, called a Smart Watch, provides a clock and calendar function with a 10-year lithium battery.

For the serial port, Tandy offers a serial Plus card. The company is also working on obtaining a hard-disk controller Plus card through a third-party vendor (estimated price: $250), which would enable users to connect Tandy's 20-megabyte hard disk ($699).

Table 1: *Here are the results of our benchmark tests, with IBM PC AT results shown for comparison.*

	1000 TX	PC AT
Dhrystone	1456	1590
Savage	38.3	37.3
Sieve	26.8	24.6
Fibonacci	131.0	126.2

Magic Ingredient

If convenience is the magic ingredient that makes a home computer worthy of the name, Tandy may have a winner in the 1000 HX. On the other hand, some important features have been left out of this package—640K bytes of RAM as a standard complement, more expansion slots, a built-in modem, and the capacity to use the 8087 floating-point coprocessor.

Tandy's marketing people have judged these features to be nonessential to the HX's target market: home users, first-time personal computer users, and elementary, high-school, and collegiate classroom users.

The LP-1000 Laser Printer

Although Tandy has manufactured a large number of printers in the past, the Tandy LP-1000 (see photo 5) is the company's first laser printer. The printer does not break any new ground in terms of technology, but, at $2199 it does have a competitive price, especially considering how much memory is included with the printer.

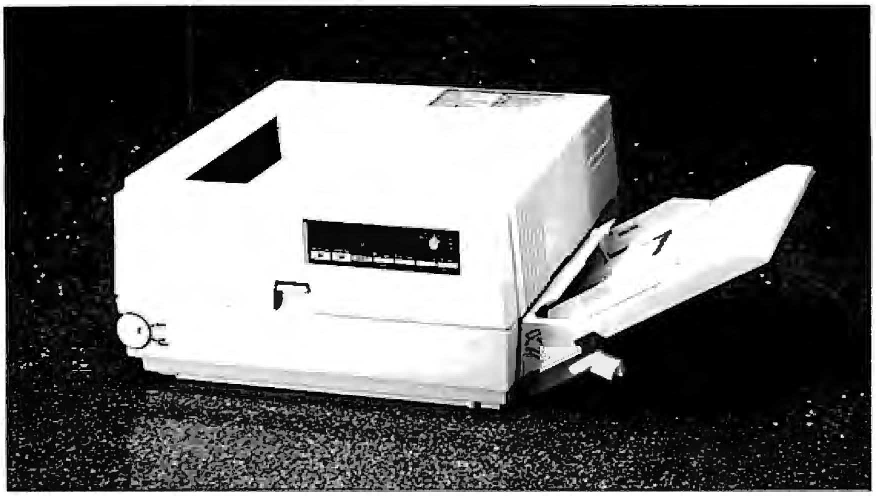

Photo 5: *The LP-1000 laser printer, a 6-page-per-minute, 300-dot-per-inch Ricoh engine printer.*

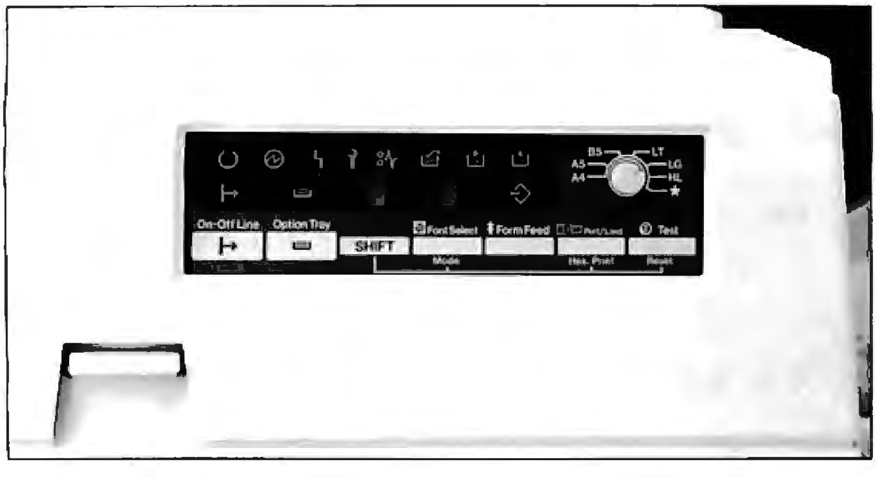

Photo 6: *The front panel of the LP-1000 laser printer.*

Like several other lasers that have come on the market this year, the Tandy printer is based on a Ricoh engine. It prints at a maximum rate of 6 pages per minute with a horizontal and vertical resolution of 300 dots per inch. Unlike many other printers, however, the LP-1000 comes standard with 1.5 megabytes of memory, enough to do full-page 300- by 300-dpi graphics.

The LP-1000 can accept letter-size or legal-size paper and has an input tray that can hold 150 sheets. The printer cannot accept envelopes, but can print on full-page label sheets. The printer stacks the printed sheets face-down in the correct order in a bin on the top of the printer. The suggested duty cycle is 3000 sheets per month.

The printer can emulate the HP LaserJet Plus, the IBM Proprinter, and the Tandy 2100 dot-matrix graphics printer. Like most laser printers, the LP-1000 has both a Centronics-style parallel interface and a video interface.

The printer can support only four fonts at any one time. Two of these are standard resident fonts, and you can download the other two. The printer does not have a socket for additional fonts. Tandy also offers a font-editing software package, which also works with its DMP 2110 dot-matrix printer, for $29.95.

The printer has no DIP switches. You can see status information and enter all changes to the printer via an LED touch panel (see photo 6) on the front of the printer. You can print out the current status of the printer at any time.

The LP-1000 is not compatible with PostScript or DDL or with any of the current controller boards that feed information through a laser printer's video interface. The company says, however, that there may be such a board available in the future, either from Tandy or a third-party manufacturer.

Not Much Missing

Tandy's current lineup of microcomputers probably represents the widest range of computers of any manufacturer in the world. These computers range from a $99 home computer to a $3499 multiuser Unix system. The company also has a sizable offering of printers, modems, and a smorgasbord of other accessories.

Only two products seem to be missing from the current collection: a write-once optical disk drive, and a CD-ROM drive. But we would not be surprised if the company were testing these devices even as these words are printed. ■

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DT2853 Frame Grabber	IBM PC AT	512x512	256	Yes	Yes	Yes	Yes	8*	Yes	Yes	2 buffers 512x512x8 each (512 Kbytes)	Yes	DT-IRIS DT/Image-Pro PC SEMPER	$1,595

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Circle 80 on Reader Service Card

Ray Duncan

The OS/2 Applications Family

A look at the variety of application types that OS/2 supports

[Editor's note: *This article was adapted from* Advanced OS/2 *by Ray Duncan, to be published in January 1988 by Microsoft Press.*]

OS/2, Microsoft's long-awaited multitasking operating system for the 80286, is designed to serve as a platform for an entirely new generation of fast, highly interactive applications with a uniform graphic user interface. It is also engineered as a crucial bridge from the 1-megabyte real-mode environment to the 1-gigabyte virtual-memory protected-mode environment.

To serve as this bridge, OS/2 can run programs with a wide spectrum of characteristics and capabilities: "old" MS-DOS applications; character-oriented, dual-mode Family Apps; character-oriented, protected-mode Kernel Apps; and Windows/Presentation Manager Apps.

This broad support has led, in turn, to much unnecessary confusion among software publishers who are trying to design and position their next wave of products and among users who are trying to reconcile their upcoming equipment purchases with their long-term software needs.

In this article, I will compare the types of programs that OS/2 can run (see figure 1), briefly touch upon the development tools that are available during the interim period until the official retail release of the operating system, and then look at a sample OS/2 program. [Editor's note: *See "A Programmer's Introduction to OS/2" by Ray Duncan in the September BYTE for an overview of OS/2 features and application program structure.*]

"Old" MS-DOS Applications

OS/2 has a special module, the DOS 3.X Compatibility Box, that allows the user to run one old MS-DOS application at a time in real mode alongside one *or more* new, protected-mode applications. The Compatibility Box is not a physical box at all; it is simply a special screen group that you can enable or disable with a directive in the system's CONFIG.SYS file. Programs loaded into the Compatibility Box run on top of an MS-DOS emulator that traps MS-DOS and ROM BIOS function calls and converts them into calls to the appropriate OS/2 services and device drivers. It also provides a realistic-looking milieu for more hardware-dependent MS-DOS programs by supporting certain undocumented MS-DOS services and internal flags, supplying a "clock tick" interrupt at the appropriate frequency, maintaining a ROM BIOS data area at segment 40 hexadecimal, and so forth.

There are, of course, a few exceptionally ill-behaved MS-DOS programs that the Compatibility Box cannot handle. These include terminate-and-stay-resident utilities, which steal hardware interrupt vectors already belonging to a protected-mode device driver, reprogram the system's 8259 programmable interrupt controller, and perform other similarly nefarious deeds.

In any event, it is important to realize that MS-DOS applications gain nothing by being run under OS/2—in fact, they run slightly slower.

The Compatibility Box is only present as a temporizing measure, to protect users' software and hardware investments until a healthy variety of protected-mode software becomes available. It is ironic that, although the 3.X box is one of the crowning technical achievements of OS/2—and one of the major factors in the delay in OS/2's release—it is destined to fade away altogether (at least from users' consciousness, though it might still be present as a historical curiosity, just as the CP/M emulator cards and programs for the IBM PC had a brief heyday after the introduction of MS-DOS and then vanished forever).

Family Apps

A Family App program is written to conform to the new OS/2 Application Program Interface (API). However, it restricts itself to those OS/2 functions that have direct counterparts in MS-DOS and that do not utilize the machine instructions unique to the 80286 or 80386. After a Family App is compiled or assembled and linked into a protected-mode executable (.EXE) file in the usual manner, it goes through an additional linkage step using the utility BIND.EXE and the library file API.LIB. The result is an .EXE file that can run in protected mode under OS/2, in real mode under OS/2 in the DOS 3.X Compatibility Box, or under MS-DOS 2.x/3.x on any 8086/88, 80286, or 80386-based machine. Such programs are sometimes called *bound* or *dual-mode* applications, and nearly all the programming tools supplied in the OS/2 software development kit fall into this category.

The executable file for a Family App actually contains both an old .EXE file header and an MS-DOS–compatible program called the stub loader, and a new .EXE file header (containing segmentation and dynamic-link information) and a protected-mode program image. If you invoke such a program under OS/2 in a protected-mode screen group, the OS/2 loader inspects the new .EXE file head-

continued

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er, brings the code and data segments that are marked "preload" into memory, resolves the dynamic links to system services, and starts up the new process in the normal fashion.

If a Family App is activated in a real-mode environment, the entire file goes into memory, and the stub loader initially receives control. The stub loader patches up each OS/2 API call within the main program to point to a routine, appended to the file by BIND.EXE, that can pop the parameters off the stack into the appropriate registers and substitute an Int 21h function call to MS-DOS. It then sets up the machine registers in accordance with OS/2's conventions and jumps to the normal entry point of the application.

A Family App is the natural first target of an experienced programmer who wants to port existing MS-DOS programs to OS/2. If said programs are already segmented according to normal .EXE file conventions, are well-behaved in their use of system memory, perform all file and record I/O using Handle function calls, and do not manipulate the keyboard or video controllers directly, then conversion is a straightforward job. The MS-DOS Int 21h calls are simply rewritten as the corresponding OS/2 API calls, and any necessary variables or structures required by the OS/2 calls are added to the program's data segment. The procedures that access command-line parameters or the environment block are adjusted appropriately, and a simple module definition (.DEF) file, describing the program's segment behavior, is created for the benefit of the linker.

Thus, transformation of an MS-DOS program into an OS/2 Family App program does not require any redesign of the program's structure or internal logic. It allows the software developer to maintain a single program and manual that can be shipped to all purchasers. On the other hand, a Family App gains little from the conversion except for the ability to execute in protected mode. Since the more sophisticated OS/2 services have no MS-DOS counterparts, they cannot be used in the program unless the developer is willing to sacrifice symmetry of its operation in all three environments. When the protected-mode Windows/Presentation Manager arrives, Family Apps will run in a window (allowing cut and paste of text from one to another) but will not support graphics operations.

Kernel Apps

A Kernel App runs only in a protected-mode screen group and uses the kernel KBD, VIO, and MOU subsystem services (i.e., keyboard, screen, and mouse I/O, respectively). Consequently, although such a program can run in a window under the Presentation Manager, it is ordinarily limited to character-oriented screen displays (if it has its own graphics drivers, it can't run in a window). On the other hand, a Kernel App has full access to OS/2's advanced features:

- It can create subprocesses (threads) that share the same data and files, child processes that run in protected memory spaces and have independent data and files, or whole new screen groups containing one or more processes writing to a separate virtual display.
- It can use all of OS/2's interprocess communication facilities (e.g., pipes, queues, semaphores, and signals) to communicate with other processes.
- It can elect to perform I/O or almost any other OS/2 operation in either synchronous or asynchronous (overlapped) fashion.
- It can create either periodic or one-shot timers and use them to schedule its own operations or those of other processes.
- It can allocate huge amounts of virtual memory.

In addition, when several protected-mode applications are closely related and contain many identical or nearly identical subroutines, you can transfer those procedures to private dynamic-link (dynalink) libraries. This reduces the size of each application's .EXE file, since the routines in dynalink libraries are bound to an application at its load time. It also allows more efficient use of memory, since concurrently executing client applications can share code segments from the library. The most important benefit of dynalink libraries, however, is simplification of code debugging and maintenance. You can modify, repair, or improve a routine in a dynalink library at any time without any change to the applications that use it, as long as you don't alter its calling sequence.

You should attempt to convert an existing MS-DOS or OS/2 Family App into a true Kernel App only after close study of both the program's fundamental mission and the services available from the OS/2 API. A clean division of the program's functionality between asynchronously executing processes or subprocesses (to fully exploit OS/2's multitasking capabilities) requires very careful planning. You must address new questions of subroutine reentrancy and synchronization of access to shared data. But the time you invest in the design phase will be amply repaid in the user's perception of application performance.

Windows/Presentation Manager Apps

Protected-mode Windows/Presentation Manager applications, like their predecessors under real-mode Windows, have a radically different internal structure and flow of control when compared to ordinary MS-DOS or OS/2 programs. The actual work performed by the program is segregated into several relatively autonomous routines known as window processors, each associated with a specific screen region, such as a parent window, a child window, a dialog box, and so on. The main routine of a Windows App is a relatively simple loop that reads a message off the program's input queue, optionally performs some translation on the message, and then redispatches the message to a window processor within the same application or in another. The message might consist of a key press, key release, a mouse movement, a signal from the system to repaint part of a window, or a notification that the application has been "iconized."

Conceptually, a Windows App requires a complete reversal of viewpoint on the part of the programmer. Instead of the application driving the environment, the environment drives the application. Instead of the application requesting a character from the keyboard or polling the mouse position when it is good and ready, the application is constantly being bombarded with messages from the system about events that are totally outside of

continued

Application Type	Runs under: MS-DOS 2.x/3.x	OS/2 Real-Mode Box	OS/2 Protected Mode	OS/2 Windows/ Presentation Manager
MS-DOS App	Yes	Yes	No	No
Family App	Yes	Yes	Yes	Yes
Kernel App	No	No	Yes	Yes
Windows App	No	No	No	Yes

Figure 1: *A comparison of various types of applications that can run under OS/2.*

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its control—and it must dispose of these messages quickly (for example, most users would consider any perceptible delay between clicking on a menu bar and the appearance of the pull-down menu as intolerably poor performance).

Aside from design considerations, a move to Windows programming requires a programmer with true grit: There is no such thing as a trivial Windows program. Even the traditional "Hello, World!" program is several pages of C code, and the logic to scroll a window correctly under all possible circumstances adds a couple more pages.

For those programmers who haven't yet gotten the message about Microsoft's love affair with C, an encounter with Windows can be a real crash landing. The Windows libraries are C libraries, the manuals and example programs assume a fluent knowledge of C, and any attempt to write a Windows App in any other high-level language or even (perish the thought) in Macro Assembler are vigorously discouraged by the Microsoft support personnel.

Needless to say, those few developers who have already written real-mode Windows applications have a significant head start, but even their lot is not easy. Although protected-mode Windows/Presentation Manager has the same user interface as real-mode Windows 2.0, the system interface at the application program level is somewhat different. Developers of Windows Apps will have to maintain two sets of source code, one for protected mode and one for real mode, and just pray that the two systems don't diverge too much over the years.

What do Windows App developers get for their pains? A dramatically shortened user learning curve, access to a battery of graphic drawing and "rich text" display functions that would take years to duplicate, ready exchange of all types of data with other Windows Apps, and eternal relief from the dreary job of writing and optimizing a new device driver for every video adapter, printer, and pointing device that appears on the market. The burden of writing a general-purpose Windows driver for new hardware is shifted to the manufacturer—where it belongs.

The Tools

The Microsoft OS/2 Software Development Kit (SDK) established some historic precedents when it landed on purchasers' doorsteps with a thump on the morning of May 29. It was certainly the most formidable software package ever shipped by Microsoft, arriving in a box nearly 3 feet long and weighing roughly 30 pounds. It was the most expensive Microsoft product ever, at a cost of $3000 per copy (to be fair, this includes automatic software updates, a year's technical support, and attendance at a three-day OS/2 seminar). It was the first time in my memory that Microsoft had delivered a product two months before its announced release date.

And last, but not least, it was the first time that Microsoft had ever asked developers to *pay* to be beta testers.

The SDK's nine high-density (1.2-megabyte) disks contain a prerelease version of the OS/2 operating system and its associated utility programs, dual-mode versions of the Microsoft C Compiler, Macro Assembler, Linker, MAKE, BIND, protected-mode CodeView, source code for many example programs, and even a fully configurable visual editor. The documentation fills eight binders, totaling some 3100 pages. The first SDKs did not include the software and documentation (an additional three manuals containing another thousand pages collectively) for the Windows/Presentation Manager graphic interface that was scheduled to be delivered as part of an update by the time this article appears.

To use the OS/2 SDK, you need a PC AT or compatible with a hard disk and at least 1.5 megabytes of RAM, room on the disk for 10 megabytes or so of programs, libraries, and example source code, and a lot of patience. The OS/2 kernel alone supports over 200 functions that can be called by application programs, and the Windows/Presentation Manager layer adds some 500 more. The days when a PC programmer could get by with a $20 MS-DOS reference book, a run-time library manual for his or her favorite language, and a quick reference card to the Intel 80x86 instruction set are gone.

An Example Kernel App

As an example of an OS/2 Kernel App to accompany this article, I have written two implementations of a file-dumping utility in C and Macro Assembler. The utility accepts a filename on the command line and displays the binary contents of that file, in hexadecimal bytes and their ASCII character equivalents, on the standard output device (and may be redirected into a file or to the printer). Such a utility is indispensable when trying to decipher the format of undocumented data files, load modules, and the like. The C source code (from the file DUMP.C) is in listing 1. [Editor's note: *DUMP.C, DUMP.ASM, and DUMP.DEF, which contain the source code for these two implementations, are available on disk, in print, and on BIX; see the insert card following page 304 for details. Listings are also available from BYTEnet; see page 4 for details.*]

Although file-dumping utilities per se are common and not very interesting, these particular programs have been intentionally complicated in order to illustrate some of the powerful capabilities of OS/2. They perform overlapped I/O by creating separate threads to handle the disk reads and screen writes.

The threads use a double-buffering scheme and coordinate their access to the buffers with semaphores. Figure 2 shows a sketch of the general logic of the DUMP program.

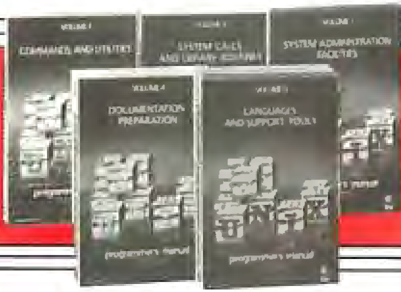
The C example demonstrates the ease with which OS/2 services may be called

continued

Listing 1: *DUMP.C, the source code for the C version of the Kernel App example.*

```
/*
        DUMP.C        Displays the binary contents of a file in hexadecimal
                      and ASCII on the standard output device.

                      Program has been deliberately complicated to
                      demonstrate direct calls from C to operating
                      system, use of multiple threads, and
                      synchronization with semaphores.

        Usage is:     C>DUMP unit:path\filename.ext
                      [ >destination ]

        Compile with: C>CL /AL /Zi /Gs /F 2000 DUMP.C
*/

#include <stdio.h>
#include <malloc.h>
#include <doscalls.h>

#define REC_SIZE 16                         /* size of file records */
#define STK_SIZE 1024                       /* stack size for threads */
```

continued



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```
char Buf1[REC_SIZE];                    /* first disk buffer */
unsigned Buf1Len;                       /* amount of data in buffer */

char Buf2[REC_SIZE];                    /* second disk buffer */
unsigned Buf2Len;                       /* amount of data in buffer */

unsigned Handle;                        /* file Handle from DOSOPEN */
long filptr;                            /* file offset in bytes */

unsigned long ExitSem;                  /* semaphore for process exit */
unsigned long Buf1FullSem;              /* semaphores for disk buffer 1 */
unsigned long Buf1EmptySem;
unsigned long Buf2FullSem;              /* semaphores for disk buffer 2 */
unsigned long Buf2EmptySem;

main(int argc, char *argv[])
{
  void far DisplayThr();                /* entry point for Display Thread */
  void far DiskThr();                   /* entry point for Disk Thread */

  unsigned DisplayThrID;                /* receives Thread ID */
  unsigned DiskThrID;                   /* receives Thread ID */

  char DisplayThrStk[STK_SIZE];         /* allocate stacks for threads */
  char DiskThrStk[STK_SIZE];
  int action;                           /* receives DOSOPEN result */
  int openflag=0x01;                    /* fail open if file not found */
  int openmode=0x40;                    /* read only, denynone */

  filptr=0L;                            /* initialize file pointer */

  ExitSem=0L;                           /* initialize semaphores */

  Buf1EmptySem=Buf1FullSem=0L;
  Buf2EmptySem=Buf2FullSem=0L;
  DOSSEMSET((long) &ExitSem);
  DOSSEMSET((long) &Buf1FullSem);
  DOSSEMSET((long) &Buf2FullSem);

  if (argc < 2)                                 /* check command tail */
  {   fprintf(stderr,"\ndump: missing file name\n");
      exit(1);
  }
                                        /* open file or exit */
  if (DOSOPEN(argv[1],&Handle,&action,0L,0,openflag,openmode,0L))
  {   fprintf(stderr,"\ndump: can't find file %s\n",argv[1]);
      exit(1);
  }
                                        /* create Disk Thread */
  if (DOSCREATETHREAD(DiskThr,&DiskThrID,DiskThrStk+STK_SIZE))
  {   fprintf(stderr,"\ndump: can't create Disk Thread");
      exit(1);
  }
                                        /* create Display Thread */
  if (DOSCREATETHREAD(DisplayThr,&DisplayThrID,DisplayThrStk+STK_SIZE))
  {   fprintf(stderr,"\ndump: can't create Display Thread");
      exit(1);
  }

  DOSSEMWAIT((long) &ExitSem,-1L);      /* wait for exit signal */

  DOSSUSPENDTHREAD(DiskThrID);          /* suspend other threads */
  DOSSUSPENDTHREAD(DisplayThrID);
  DOSCLOSE(Handle);                     /* close file */
  DOSEXIT(1,0);                         /* terminate all threads */
}

/*
        The Disk Thread reads the disk file, alternating between Buf1
        and Buf2. This thread gets terminated externally when the
```

continued

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* Using the suite of 48 comprehensive benchmarks published in Data Based Advisor, March 1987.

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```
      other threads (see end of file) have been reached.            */
void far DiskThr( )
{
  while(1)
  {    DOSREAD(Handle,Buf1,REC_SIZE,&Buf1Len); /* read disk */
       SemFlip(&Buf1EmptySem,&Buf1FullSem);    /* mark buffer 1 full */
       DOSSEMWAIT((long) &Buf2EmptySem,-1L);   /* wait for buffer 2 empty */
       DOSREAD(Handle,Buf2,REC_SIZE,&Buf2Len); /* read disk */
       SemFlip(&Buf2EmptySem,&Buf2FullSem);    /* mark buffer 2 full */
       DOSSEMWAIT((long) &Buf1EmptySem,-1L);   /* wait for buffer 1 empty */
  }
}

/*
      The Display Thread formats and displays the data in the disk
      buffers, alternating between Buf1 and Buf2.          */
void far DisplayThr( )
{
  while(1)
  {    DOSSEMWAIT((long) &Buf1FullSem,-1L);    /* wait for buffer 1 full */
       DumpRec(Buf1,Buf1Len);                  /* format and display it */
       SemFlip(&Buf1FullSem,&Buf1EmptySem);    /* mark buffer 1 empty */
       DOSSEMWAIT((long) &Buf2FullSem,-1L);    /* wait for buffer 2 full */
       DumpRec(Buf2,Buf2Len);                  /* format and display it */
       SemFlip(&Buf2FullSem,&Buf2EmptySem);    /* mark buffer 2 empty */
  }
}

/*
      Display record in hexadecimal and ASCII on standard output.
      Clear exit semaphore and terminate thread if record length=0. */
DumpRec(char *buffer, int length)
{
  int i;                                /* index to current record */

  if (length==0)                        /* check if record length = 0 */
  {  DOSSEMCLEAR((long) &ExitSem);      /* yes, signal main thread */
     DOSEXIT(0,0);                      /* and terminate this thread */
  }

  if (filptr % 128 == 0)                          /* maybe print heading */
     printf("\n\n      0 1 2 3 4 5 6 7 8 9 A B C D E F");

  printf("\n%04lX ",filptr);            /* file offset */

  for (i = 0; i < length; i++)          /* print hex equiv. of each byte */
     printf( " %02X", (unsigned char) buffer[i] );

                                        /* space over if partial record */
  if (length != 16) for(i=0; i<(16-length); i++) printf("   ");

  printf("  ");

  for (i = 0; i < length; i++)          /* print ASCII equiv. of bytes */
      {  if (buffer[i] < 32 || buffer[i] > 126) putchar('.');
         else putchar(buffer[i]);
      }

  filptr += REC_SIZE;                   /* update file offset */
}

/*
      Since there is no operation to wait until a semaphore is set, we
      must maintain two semaphores to control each buffer and flip          */
      them atomically.
SemFlip(long *sem1, long *sem2)
{  DOSENTERCRITSEC( );                  /* block other threads */
   DOSSEMSET((long) sem1);              /* set the first semaphore */
   DOSSEMCLEAR((long) sem2);            /* clear the second semaphore */
   DOSEXITCRITSEC( );                   /* unblock other threads */
}
```

directly from a high-level language. The assembly language version, DUMP.ASM, also contains two procedures that Macro Assembler programmers should find useful in other programs. The routines are called ARGC and ARGV, and they return the number of command-tail arguments and pointers to those arguments, similar to C's argc and argv.

Assembling and Linking DUMP.ASM

First, use the Microsoft Macro Assembler to assemble the file DUMP.ASM into the relocatable object module DUMP.OBJ with the following command line:

```
[C:\] MASM /L /Zi DUMP
```

The optional /L and /Zi switches in the MASM command line request the creation of a program-listing file and the inclusion of symbolic debugging information in the relocatable object file, respectively.

To link the file DUMP.OBJ, the module-definition file DUMP.DEF, and the OS/2 API dynalink reference file DOSCALLS.LIB into the executable application DUMP.EXE, enter:

```
[C:\] LINK DUMP,,,DOSCALLS,DUMP
```

You can then run the DUMP utility with a command of the form:

```
[C:\] DUMP MYFILE.DAT
```

Compiling and Linking DUMP.C

The C compiler has a control program, CL.EXE, that automatically runs the preprocessor, the various passes of the compiler, and the linker for you. To compile and link the file DUMP.C, together with the library DOSCALLS.LIB and the module-definition file DUMP.DEF, into the executable DUMP.EXE, enter the command line:

```
[C:\] CL /AL /Zi /Gs /F 2000
      DUMP.C
```

The /AL switch specifies a "large model" program, while the /Zi switch (again) specifies that the linker should include symbolic debugging information in the object module and in the final executable file. I prefer to use the large model for most of the OS/2 utility programs I write in C because the compiler then generates "long" addresses for the parameters supplied in direct calls to OS/2 services without the need for any special typecasting.

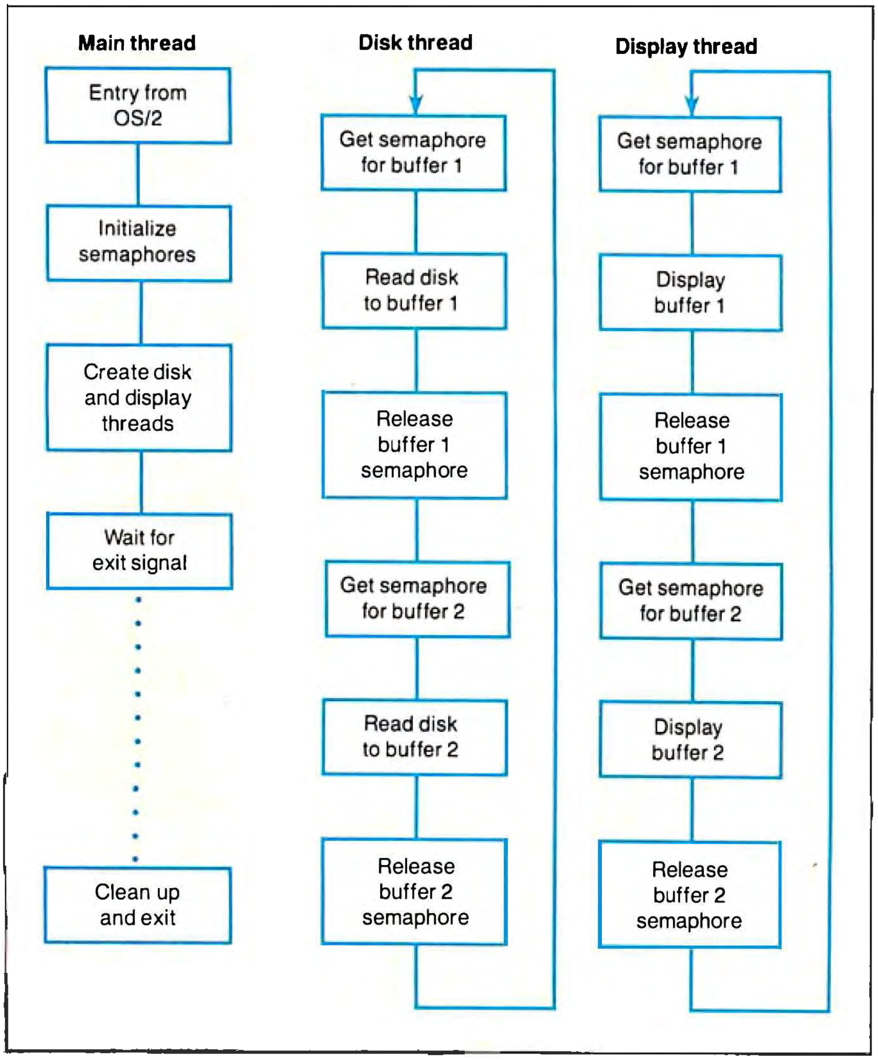

Figure 2: *A sketch of program logic for the DUMP example program. Separate subprocesses (threads) are used to perform the disk file reads, and the formatting and display. Two semaphores provide mutual exclusion on the I/O buffers. The main thread simply waits until the other two threads are done, unless a critical error or other external event activates it in the meantime.*

To Port a Program

If you want to port an existing MS-DOS application to OS/2, or develop an entirely new OS/2-based product, you must make some early implementation decisions based on the specific characteristics and needs of your application.

You can quickly port products that require a minimum of user interaction and have no need for graphics, such as compilers, linkers, and similar tools, to OS/2 as Family Apps. This gives you the added advantage of being able to ship a single disk and manual for MS-DOS 2.x/3.x, the OS/2 DOS 3.X Compatibility Box, and OS/2 protected mode.

You can write highly interactive applications with no need for graphics (e.g., communications programs) as character-oriented Kernel Apps and reap the benefits of OS/2's protected-mode services. While not as straightforward as a Family App port, a Kernel App is still relatively easy to write and will run in a window under the Presentation Manager, if necessary. Most of the commercial products released for OS/2 in the next year or so will undoubtedly fall into this category.

Finally, if you need to port graphics-oriented applications to OS/2, you have a choice between revamping your program as a true Windows/Presentation Manager App, or going it alone and providing your own graphics routines. If you choose the latter course, your program might be published sooner, but it will lose the ability to run in a window alongside of (and exchange data with) other Windows/Presentation Manager Apps, and you forfeit the advantages of the common graphic user interface. You will also waste time writing hardware-dependent drivers that might be better spent on user-oriented enhancements. ■

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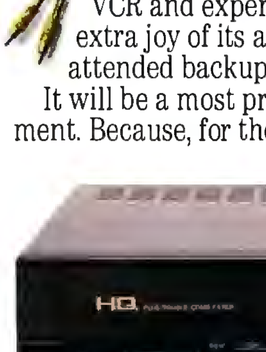

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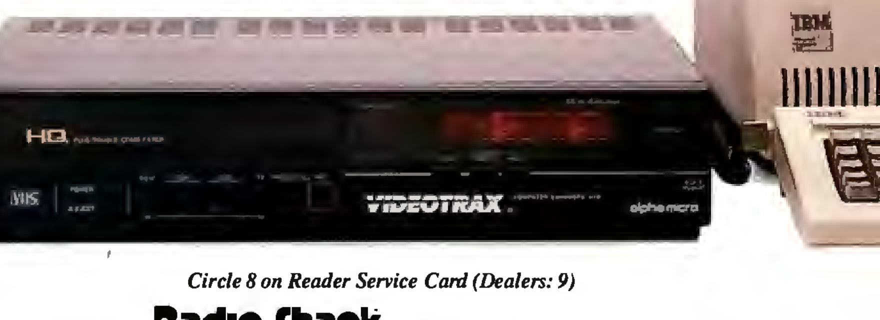

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Ezra Shapiro

A Spiritual Heir to the Macintosh

The Canon Cat may be Jef Raskin's long-sought "information appliance"

Editor's note: *The following is a BYTE product preview. It is* not *a review. We provide an advance look at this new product because we feel it is significant.*

The Canon Cat is being advertised as a piece of office equipment—the next step beyond the memory typewriter—but there's some real computer muscle under this feline's skin. It's Jef Raskin's first machine since he left Apple, where he headed the original Macintosh development team. And, as you might expect from this pedigree, the Cat takes an innovative approach to computing in the business environment.

Like the Macintosh, the Cat is a one-piece unit with a 9-inch black-and-white bit-mapped monitor, a single 3½-inch floppy disk drive, a small footprint, a Motorola 68000 CPU, and a user interface built into ROM. However, that's where the similarity ends; the Cat has no mouse, no icons, and no graphics.

Raskin's goal at Apple had been to create a low-cost, minimalist "people's computer." However, as the Macintosh evolved into a product, it grew in scope, complexity, and cost. A year after his departure from Apple in 1982, Raskin founded a small company and began to design a machine that would recapture his original vision; he named the firm Information Appliance, a rather succinct statement of his utilitarian philosophy.

The company is still going strong. The Canon Cat is a refinement of the prototypes developed by Raskin and his coworkers at Information Appliance and is now being manufactured and sold by Canon U.S.A. under a series of technology licenses.

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.

At First Glance

The 17-pound Cat takes about as much space as an Apple IIc with a monitor, standing $10^{11}/_{16}$ inches tall with a footprint 13⅛ inches wide and 17¾ inches deep. The CRT display is tilted back from the keyboard at a comfortable viewing angle; the screen is slightly to the left of center. A 3½-inch floppy disk drive is mounted vertically next to the screen in the right-hand section of the integrated housing.

Outputs include a Centronics parallel port, a 25-pin RS-232C serial port, and two Telco RJ-11 jacks to connect the Cat's internal 300/1200-bit-per-second

continued

Photo by Paul Avis

IN BRIEF

Canon Cat

Company
Canon U.S.A. Inc.
One Canon Plaza
Lake Success, NY 11042-9979
(515) 688-7000

Size
10 11/16 by 13 1/8 by 17 3/4 inches;
17 pounds

Components
Processor: 68000 running at 5 MHz
Memory: 256K bytes
Mass storage: One 256K-byte internal 3½-inch floppy disk drive
Display: 9-inch black-and-white built-in bit-mapped screen
Keyboard: Compatible with IBM Selectric typewriter plus control functions on front of key caps
I/O interfaces: One Centronics parallel port, one RS-232C serial (DB-25) port, and two RJ-11 jacks (one to external telephone, one to telephone line)
Modem: Internal 300/1200 bps

Software
Contained in ROM, it includes word processing, mail merge, calculation, communications, data retrieval, and programming in Forth or assembly language

Price
$1495

modem to an incoming telephone line and an external telephone. The modem uses the Hayes command set and can be configured either for regular ASCII communications (including auto-answer) or as a simple telephone dialer.

The machine's motherboard, boasting a 5-megahertz 68000 and 256K bytes of dynamic RAM, lies flat underneath the display. Software for the Cat is built into 256K bytes of ROM, with an additional 128K bytes that contains the system's built-in spelling checker, a 90,000-word version of *The American Heritage Dictionary*. Setup parameters and a small personal dictionary are stored in 8K bytes of CMOS RAM, backed up with a lithium battery.

Putting the Cat to Work

It's the software for the Cat that really shows off Raskin's conceptual touch. The basic interface is a simple text editor; you can sit down at the keyboard and just start typing. Initial defaults are set for a standard business page, so a novice can begin producing letters and memos almost immediately.

The Cat's full-size keyboard is almost identical to those of the IBM Selectric typewriter and its competitors. Although several new keys have been added to the layout, the business typist will notice no anomalies. The period and comma keys, for example, generate those characters in either shifted or unshifted mode.

While the tops of the key caps adhere to the office standard, computer commands are printed on the front face of many of the keys. The *L* key is marked Disk, the *J* key is marked Print, and so on. You trigger these special functions the same way you use Control-key combinations on a computer keyboard. However, the Cat's Control key is labeled simply Use Front—meaning use the command that is printed on the front of the key cap.

So, for example, to access the context-sensitive help screens (48K bytes' worth), you press the Use Front key together with the *N* key, which says Explain on the front of its key cap. A Setup command—the ¼/½ key—lets you change system parameters like margins, printer types, character set, and so on. An Undo command lets you reverse your last action.

The display looks as much like a typewriter with a sheet of paper as you can get on a CRT screen. Black characters on a white background extend upward from a white-on-black ruler bar at the bottom of the display. Margins are indicated with a hollow box superimposed on the ruler bar; the effect is similar to a typewriter's paper bail. Small symbols below the ruler show line spacing, justification, memory usage, and so on.

The Cat holds 160K bytes in RAM, which is roughly equivalent to 80 single-spaced typewritten pages. You move through your data by holding down one of two extra keys located in front of the spacebar and typing a string of characters; the Cat jumps to the next occurrence of that string. The right-hand key initiates forward searches; the left-hand key, backward searches. If the search string doesn't find a match, the cursor returns to your starting position. In Cat jargon, these two keys are called Leap keys.

Raskin claims that scrolling from the top to the bottom of a full 8½- by 11-inch page takes 8 seconds if you're pressing a cursor key, 4 seconds if you're using a mouse and scroll bars, and only 2 seconds with this Leap-key search mechanism. The disparity becomes more pronounced if you're trying to move longer distances with any precision.

Aborting a Leap operation is as easy as adding a few nonsense characters to the search string; the Cat won't be able to find it, and you'll be back where you started. Raskin suggests slapping your hand lightly in the center of the keyboard, an action likely to produce the required gibberish.

The Leap keys are also used to highlight text. You can delete, copy, or move highlighted blocks or check them for spelling mistakes with the built-in dictionary. If a highlighted block happens to be a mathematical formula, one keystroke calculates the result. The answer appears on the screen with a dotted underline; highlighting it and hitting a command sequence reveals the original formula, which you can then edit and recompute.

If the highlighted text is a computer program written in either Forth or 68000 assembly language, the Cat executes it. You can use a highlighted columnar table as the raw data for a full mail merge. Since you can assign sequences of commands mixed with text to each of the numeric keys at the top of the keyboard (accessed with the Use Front key), you can create complex macros or store boilerplate text.

One keystroke also dials a highlighted telephone number either for voice communications or to initiate a session with a remote computer; ASCII data simply flows into RAM as a long text document, which you can then manipulate as you would any other text. The incoming data stream is buffered in RAM, so if it doesn't require constant attention, you can move to another document and continue working.

Documents and Disks

The Cat environment is essentially one long text stream broken into pages. The software automatically inserts page breaks, but you can force a new page or start a new document whenever you want to. Forcing a document break resets a page-number counter to zero. Independent files do not exist per se, but if you don't want to use Leap searches to locate a specific document, the Cat lets you assign a title to any region started with a forced document break.

The machine uses a 256K-byte disk format, which holds the entire contents of the Cat's RAM plus configuration parameters, personal additions to the dictionary, system information, and a bit map of the last screen saved to disk.

There are several advantages to this system. First, you're always working in RAM, so you're always at full speed. Disk operations are reduced to swapping the entire load of RAM, which reduces the risk of error. If you plug a disk into an idle Cat, it loads the contents of the disk, and you're ready to go. If the disk is unformatted, the Cat beeps at you: Executing the Disk command formats the disk and starts you off with a clean slate.

If you pull your disk out of the machine without saving, the Cat beeps. Insert the disk, and the Cat saves and continues. Insert a blank disk, and the Cat formats and saves your current RAM. Insert an already-used Cat disk, and the Cat beeps again, inquiring if you really want to erase it and save the current RAM; you have to hit the Disk key again to erase the disk.

Second, because each disk contains all configuration information as well as data, if you move a disk to another machine, you move your environment with you. You don't have to hassle with setting up parameters every time you switch Cats; that's all done automatically.

Finally, storing the image of the screen gives you the impression that load operations are extremely fast. It takes about 20 seconds to load a full disk into RAM, but only about 2 seconds to recall the screen data. Rather than waiting impatiently as the disk drive hums along, you're shown your work environment almost immediately, and you can use the remaining load time to figure out what you're going to do.

Low-Hassle Computing

The Cat represents an eye-opening new approach to data storage and retrieval; it will surprise anyone who thought that interface design was a dying art. Though the basic configuration appears on the surface to be a flexible word processor, the Cat's computational, macro, and programming capabilities make it quite possible to build data structures that emulate spreadsheets and databases.

The seeming formlessness of the environment may cause some initial hesitation if you are accustomed to the complexity and rigidity of current application packages, but it's easy enough to start small—with rudimentary typed documents—and graduate to more sophisticated operations as you need them. What's more, you've got the whole thing in a tidy package that clerical workers and executives alike won't find threatening.

Whether the Canon Cat is truly an "information appliance" is hard to say. Its $1495 price tag forces it into competition with low-cost MS-DOS clones and discounted Macintoshes—not a good position for a "people's computer." However, the Cat's unique interface could make it a strong contender; it's certainly worth a look, particularly if you're interested in low-hassle computing. ■

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Dick Pountain

The Archimedes A310

Probably the world's fastest personal computer, the Archimedes is also the first RISC machine inexpensive enough for home use

Editor's note: *The following is a BYTE product preview. It is* not *a review. We provide an advance look at this new product because we feel it is significant.*

At prices that start below £1000—approximately $1600—Acorn's new Archimedes is the first machine to offer reduced-instruction-set-computer technology to home users. Powered by the ARM (Acorn RISC machine) chip, the Archimedes comes in two series. The A300 computers are low-cost machines for school and home use that bear the name of the BBC, like Acorn's previous 6502-based BBC Micro. The A400 series, to be launched later this year, will feature fast hard disk drives, more memory, and expansion slots. The computers in the A400 series will be professional workstations.

Acorn's Archimedes

The machine Acorn lent me for this article was an Archimedes Model A310 (see photo 1) that features 1 megabyte of RAM and a single 3½-inch floppy disk drive. Its floppy disks have a capacity of 800K bytes. The A310 runs a new proprietary operating system called Arthur that provides some compatibility with the BBC Micro. Arthur is contained in the machine's 512K bytes of ROM, along with an advanced BASIC interpreter. A desktop-style interface is forthcoming.

The Archimedes supports color graphics with resolutions up to 640 by 512 pixels and as many as 256 colors from a palette of 4096. It also supports eight channels of stereo sound. It uses no custom hardware to support either the graphics or the sound; sound synthesis and blitting are done purely by "ARM power."

The machine comes standard with a parallel printer interface, an RS-423 serial interface (Acorn has used this standard in preference to RS-232C for years on the BBC Micro), outputs for composite monochrome and analog RGB video, and connectors for both stereo headphones and Acorn's proprietary Econet network. The computer also sports a three-button mouse.

Acorn offers three monitor choices for the Archimedes: a black-and-white monitor, a medium-resolution color monitor capable of 640 by 256 pixels in 256 colors (see photo 2), or none at all. The latter option lets you supply the NEC MultiSync or equivalent monitor that you need to use the highest-resolution screen mode (640 by 512 pixels in 16 colors).

The A310 sells in the U.K. for £875 with no monitor, £925 with the monochrome monitor, and £1075 with the color monitor. The A305, which in-

continued

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Photo 1: *The Acorn Archimedes A310.*

cludes 512K bytes of RAM, costs £799 with no monitor, £849 with the monochrome monitor, and £999 with the color monitor.

The Hard Facts

The A310 is about the same size as an IBM PS/2. The 3½-inch floppy disk drive slopes so you insert disks at a slight downward angle, which is more natural for your hand. As soon as the drives are available, you should be able to upgrade to a second floppy disk drive for £125.

A detached 102-key keyboard follows the IBM Enhanced layout, although two or three keys have alternative names for compatibility with earlier Acorn machines (e.g., the End key is also called Copy). The three-button mouse plugs into a socket on the keyboard rather than on the system unit.

A single multilayer double-sided motherboard contains all the electronics, including four large JEDEC (Joint Electronic Device Engineering Council) carriers that contain the ARM and its three companion chips. Thirty-two RAM chips are hidden away under a metal bridge that supports the floppy disk drive. These are 64- by 4-bit devices, 16 soldered and 16 socketed (the latter would be empty on an A305). There is also a battery-backed 256-byte CMOS static RAM that the clock/calendar and the operating system use to store configuration parameters.

The motherboard contains a 64-pin bus-extender socket. This isn't an expansion slot per se; it's designed for an optional backplane board that holds two real expansion slots. Acorn calls the cards that fit in these slots *podules*. (The backplane is also used for a controller card if you add a hard disk drive to the A310.)

The podules Acorn plans to release include network cards (for Econet and Ethernet), ROM cards containing application software, a MIDI (musical instrument digital interface) sound card, an extended I/O card, an 80186 coprocessor to run IBM software, and a floating-point coprocessor.

The A300 and A400 machines diverge most sharply in the area of expansion. The A300 machines can accept only two podules (after you add the optional backplane), and they can't use coprocessors that need access to the system data bus. The A400 machines come with four slots, have Econet built in (thus saving a slot), and can accept coprocessors.

The A310 I previewed came with Acorn's medium-resolution color monitor, a straightforward analog RGB unit that connects to the Archimedes via a SCART socket (also known as a Euroconnector) and has the main controls and power switch mounted on the front. The color quality is excellent, but text definition is only adequate at 80 characters per line; it is somewhat better than an IBM CGA's text definition, but not as good as an EGA's. The Archimedes also supports 132-character text modes, but I found them too tiring for prolonged use; they might be usable on an NEC MultiSync or equivalent monitor.

A Designer Chip Set

The architecture of the Archimedes—a blend of simplicity and sophistication—depends heavily on three peripheral chips designed by Acorn specifically to complement the ARM. The ARM itself is a 32-bit RISC processor (see "How Much of a RISC?" by Phillip Robinson in the April BYTE and my "BYTE U.K.: The Acorn RISC Machine" in the January 1986 BYTE). Its design deliberately resembles a 6502 brought up to date with short, fast instructions and a superfast interrupt response time.

The three peripheral chips are IOC, the I/O controller; VIDC, the video controller; and MEMC, the memory controller. Along with the ARM, they are fabricated in 2-micron CMOS. By putting a lot of carefully chosen functionality into these three chips, Acorn has created a designer chip set to which you need add only RAM and disk controllers to make a computer. The chips are optimized to work together and to exploit the large processor-to-memory bandwidth better than an assemblage of off-the-shelf chips.

The IOC chip controls system interrupts and the system bus. It contains a number of timers, a serial keyboard interface, and logic for talking to peripherals like disk controllers and serial chips.

The VIDC chip contains 46 control registers and three 32-bit-wide first-in/first-out buffers for direct-memory-access transfer of video, sound, and cursor data. It can control a color display with 1, 2, 4, or 8 bits per pixel (i.e., from monochrome up to 256 colors) and with a colored border. It includes an on-chip 16-word color-lookup palette (allowing a choice of 4096 colors) and three on-chip D/A converters to directly drive the guns of an RGB monitor. VIDC supports a hardware cursor in any of three colors, and it permits programmable control over the VDU (video display unit) timing parameters, including an interlaced mode.

The pixel rate is programmable to 8, 12, 16, or 24 megahertz, which translates to a maximum of 640 by 256 pixels in 256 colors or 640 by 512 pixels in 16 colors. As an added feature, the 4 bits normally supplied to the red D/A converter are output on separate pins; external logic can serialize the bits to give a pixel stream four times the chip speed, or up to 96 MHz. Thus, with a suitable monitor, the VIDC chip can support a 1024 by 1024 high-resolution monochrome display.

The VIDC chip also supports sound synthesis, using a four-word FIFO buffer and an 8-bit latch driving a 7-bit D/A converter; sound signals are produced from the D/A converter output by integration and subtraction using external logic. The chip can handle from one to eight sound channels in stereo, and a dedicated VIDC register controls the stereo-image position for each channel.

The MEMC chip can address and refresh up to 4 megabytes of dynamic RAM, and it translates between logical

continued

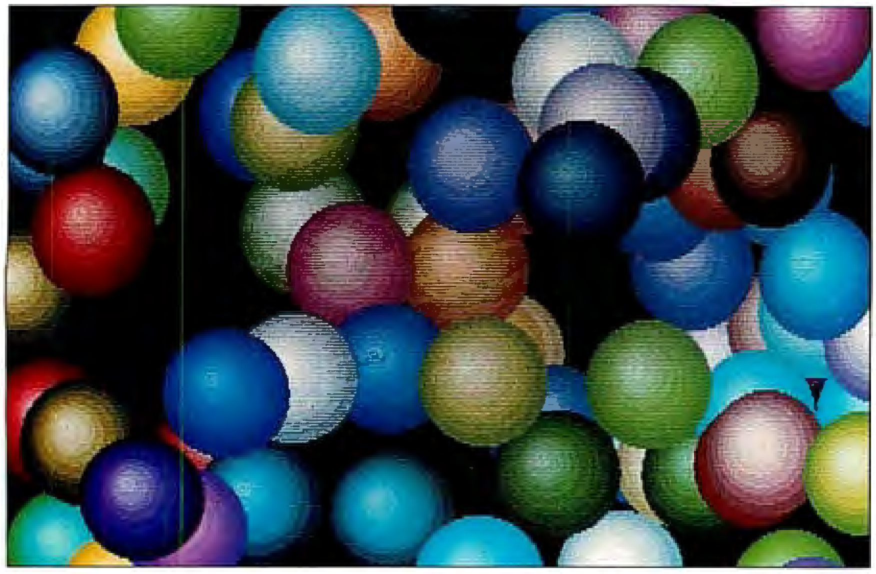

Photo 2: *An example of the Archimedes screen at 640- by 256-pixel resolution with up to 256 colors.*

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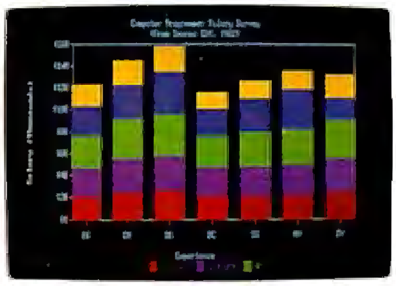

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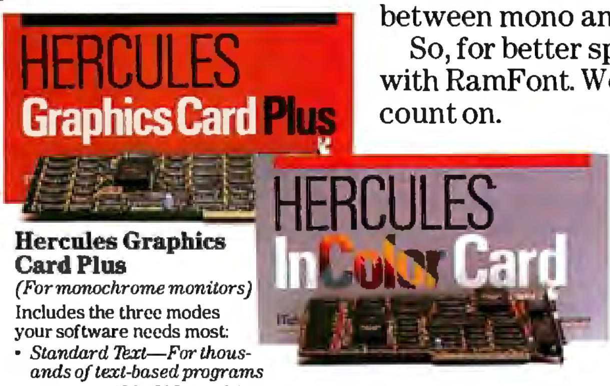

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*Multiplan French and German version now available. English version available fall 1987.

and physical addresses to give a 32-megabyte logical-address space. It provides memory protection with three levels of access privilege: supervisor mode, operating system mode, and user mode. The MEMC also doubles as a DMA controller to manage the buffers for video, sound, and cursor data. Finally, it provides the processor-clock signal and all other system-timing signals; thus, it is the glue that holds the four chips together.

A Map of the Interior

In the Archimedes machines, the MEMC "sits" on the address bus, mapping all ARM 26-bit addresses into 22-bit virtual addresses and arbitrating between the ARM and the VIDC during DMA transfer for video, cursor, or sound data. The Archimedes has no dedicated video RAM; the screen buffer can exist in any portion of RAM (you can program its start address through the MEMC). None of the RAM needs to be dual-ported; the VIDC can always get DMA access to the screen by requesting it through the MEMC. The screen buffer is contiguous, not bit-plane-organized, and the VIDC simply groups adjacent bits together according to the color mode selected.

The MEMC supports page-mode memory access for greater speed when accessing adjacent addresses. A slow memory cycle sets the row and column addresses of the RAM. After that, fast cycles in which the MEMC only needs to alter the column address are permitted. Up to three fast cycles can occur before another slow cycle is required. The MEMC actually clocks the ARM at twin speeds: 4 MHz for the slow cycles and 8 MHz for the fast cycles.

When the MEMC receives a nonsequential-read request, it cancels the 8-MHz cycles. It always reads ROM at 4 MHz, which gives you a speed bonus for working in RAM. Since a large percentage of computer operations take place on sequential data (e.g., fetching most program instructions or moving a block of screen data), you can nearly double the effective throughput without using expensive static RAM. The DRAMs on the A310 I used had a 120-nanosecond access time. Since most ARM instructions execute in one cycle, the processing rate on mixed data probably exceeds 6 million instructions per second.

The VIDC is optimized to take advantage of the MEMC's page-mode access. The VIDC loads video data into its FIFO buffer four 32-bit words at a time. For most video accesses, this means the first word transfers at 4 MHz and the next three at 8 MHz.

You can, in principle, use the MEMC to provide a disk-based, demand-paged virtual memory system, or to provide hardware memory protection for multitasking by stopping one task from interfering with another's memory. However, Arthur uses it more simply.

The ARM can address 64 megabytes with its 26-bit address bus. The MEMC maps this space as shown in figure 1. Only the bottom 32 megabytes of logically mapped RAM are available in user mode; all the higher addresses are restricted to supervisor and operating system modes. You can address up to 12 megabytes of ROM, of which the 512K-byte built-in operating system takes a portion. In principle, 16 megabytes of physical RAM could be present, but the current MEMC chip restricts this to the lower 4 megabytes (a limitation of the MEMC chip rather than the ARM).

The logical memory mapping provides great programming flexibility. The operating system can use addresses that are guaranteed regardless of how much real memory the machine contains. For example, the video-screen memory sits at the top of user memory (i.e., the thirty-second megabyte of the bottom 32 megabytes of logically mapped memory), and it grows downward as more is needed for the higher screen modes. This address remains the same on all models, from the 512K-byte A305 to the 4-megabyte A440. The system heap can allocate and reclaim pieces of memory from anywhere in physical memory, with no problems about loading order; contrast this with MS-DOS, where you can't reclaim freed memory stuck below a resident program without rebooting.

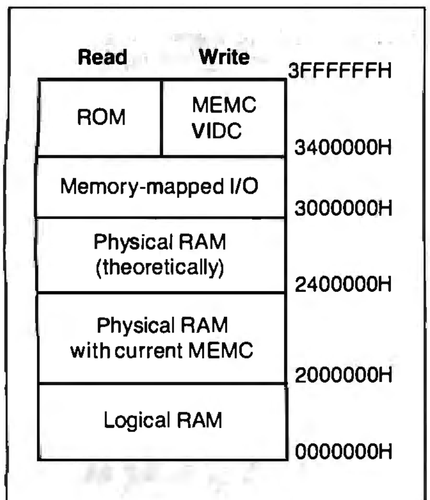

Figure 1: *Memory mapping on the Archimedes.*

Operating With Arthur

Arthur is new but derives much of its design from the BBC Micro's 6502 operating system Acorn wrote in 1979. It is quite different from the CP/M and MS-DOS operating systems in philosophy.

For a start, Arthur segregates the machine operating system (MOS) proper from the disk filing system. The Archimedes comes with two alternative filing systems: the ADFS (advanced disk filing system), which supports both 640K- and 800K-byte floppy disk formats, and the ANFS (advanced network filing system), which supports file sharing via Econet. You change filing systems merely by loading a module from disk (i.e., type `ADFS` or `NET` at the MOS prompt).

Under Arthur, all files consist of a stream of bytes on the disk with no header; filename extensions are not supported. File-type information determines how Arthur treats a file; this information is stored not in the file itself but in 64 bits in the file's directory entry. Arthur uses these 64 bits in various ways. For executable binary files, they are two 32-bit addresses: the load address and the execution address. Programs can load and run from anywhere in memory, and many programs may be coresident.

Although Arthur is not a multitasking operating system, the memory management scheme makes it easy to add multitask scheduling at the application level; Acorn's Twin editor uses this scheme to allow compilers to run in the background. Arthur also manages storage for graphics and sound data.

The command-line interface, which has an asterisk prompt, understands the same sort of commands as other operating systems, such as those needed to manage disk drives and files and support hierarchical directories like those in later versions of MS-DOS. The actual commands, however, are different, but you can change them to the familiar commands with a special `set alias` facility if you wish.

If command-line interfaces make you nervous, the Desktop front-end program conceals Arthur. For now, you must boot this program from disk. When it is finished, however, it will live in ROM. The Desktop looks like a cross between GEM and Windows. The copy I reviewed was in an early stage of development, but, even so, its response time was superior to the Macintosh's or GEM's, and it already lets you open subdirectory icons and launch programs by double-clicking. You can't yet pass parameters to a clicked program or pop desk accessories up from inside an application, but these and other features are coming.

The operating system also contains a powerful BASIC-like command language that you can use to create macros and new

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Table 1: *BYTE BASIC benchmarks (times are in seconds); the Archimedes results are preliminary.*

	Write	Read	Sieve	Calculations
Archimedes A310				
ROM BASIC V	15.8	15.6	7.9	3.2
RAM BASIC V	15.8	15.6	6.0	2.4
Compaq Deskpro 386	25.0	24.0	21.0	6.8

Table 2: *BYTE C benchmarks (times are in seconds); the Archimedes results are preliminary.* [*Editor's note:* We have omitted the Float benchmark in C because the ARM C compiler essentially optimizes it to nothing.]

	Acorn Archimedes A310	Compaq Deskpro 386	Mac SE with HyperCharger
Fib	52.4	53.1	71.6
Sieve	5.7	6.0	14.9
Sort	10.0	5.6	20.6
Savage	91.2	21.5	8.8
Dhrystones per second	4901	3748	2176

Table 3: *BYTE C benchmarks that I have converted into BASIC V to find out what difference compilation makes (times are in seconds).*

	Fib	Savage
Archimedes A310		
ROM BASIC V	2868.4	45.5
RAM BASIC V	2174.1	32.8

commands and define environment variables.

The only thing I missed in Arthur was a good general-purpose system editor. The BASIC editor is powerful, but it can't open batch or text files. Acorn has a fast and powerful editor called Twin (so-called because it can split the screen into two windows), but you have to buy this separately as part of the Programmer's Toolkit.

A Welcome disk comes with the Archimedes; it contains the Desktop program, some tutorials, and a number of demonstration programs (including some games) that illustrate the power of the ARM. The Welcome disk also contains various utilities, like 65Arthur, a software 6502 emulator that lets many programs for the BBC Micro run on the Archimedes.

How Fast Is It?

Acorn claims that the Archimedes is the fastest personal computer in the world, which makes the task of benchmarking it more than usually sensitive. I ran the BYTE BASIC benchmark tests twice, once from ROM and once from RAM, because of the difference in access speed on this machine (see table 1). I ran the ROM set in ARM BBC BASIC V (the BASIC built into the Archimedes ROM). The RAM set used the RAM-resident version of BASIC V that comes on the Welcome disk.

I tested the BYTE C benchmarks (see "A Closer Look" in the September BYTE) using Acorn's ARM C compiler (see table 2). I also ran the Fibonacci and Savage benchmarks in BASIC V to find out what difference compilation makes (see table 3). While Fibonacci takes *much* longer in BASIC V, Savage runs twice as fast in BASIC V as it does in C on the Archimedes because the C compiler uses less efficient (but, at 64 bits, more precise) IEEE emulation routines.

The results suggest that Acorn's claim is not idle boasting, although, as with all benchmarks, there are wins and losses, and none of them tells the whole story. What I can say with certainty is that the Archimedes running C programs *without* a math coprocessor rivals the Compaq Deskpro 386, a 16-MHz 80386 machine *with* an 8-MHz 80287, and comfortably outpaces a Macintosh SE with a Hyper-Charger, a 15.67-MHz 68020 with a 7.83-MHz 68881, on all but the floating-point-intensive Savage benchmark (the Compaq also beats the Archimedes on the Sort). Even more remarkably, the Savage benchmark in interpreted BASIC V in RAM on the Archimedes takes only half again as much time as it takes in compiled C on the Deskpro 386 with a math coprocessor.

Benchmarks are not everything, but the experience of using the Archimedes tells me that on many untested tasks, like writing to the screen, it is far faster than anything else I've seen. If I had to take a stand on benchmark figures alone, I would look at the Dhrystone, which is the most general-purpose test (even though it doesn't test floating point). The Archimedes runs 31 percent more Dhrystones per second than a Compaq Deskpro 386.

It's a Winner!

The Archimedes really does offer RISC power within the budget of the serious home user. What's more, it is extraordinarily inexpensive compared to its only serious competitors, the Macintosh II and the various 80386 machines.

The Archimedes really does offer RISC power to the home user. Its color graphics rival those of the Macintosh II and the IBM VGA, and they far exceed existing IBM standards. It's a boon to scientists and engineers who need to write their own high-performance software because it is no more difficult to program than the old Apple II. However, when provided with a hard disk drive and suitable applications, it also makes an excellent vehicle for desktop publishing and workstation roles.

Cynics can fairly point out that since the Archimedes lacks either an Intel or a Motorola microprocessor, it bucks the industry standards and lacks a software base. But there are times in computer evolution when you must make a quantum leap and leave existing standards behind to advance the technology; Apple did this when it came out with the Macintosh, and Commodore did it—rather less successfully—when it came out with the Amiga. I believe that the Archimedes is such an attractive hardware package—at such an attractive price—and so easy to write for compared to the Macintosh, Amiga, or Atari ST (thanks to its memory management hardware), that it will quickly promote a substantial base of software.

We should also remember that Acorn is owned by Olivetti, the most successful computer firm in Europe—and by no means negligible in the U.S., thanks to its deal with AT&T. The Acorn people have not finalized their plans for selling the Archimedes in the U.S., and it's not clear whose name will be on the machine when they do. The Archimedes is on sale now in the U.K., and you can get more information on it from Acorn Research Centre (5 Palo Alto Square, Suite 910, 3000 El Camino Real, Palo Alto, CA 94306, (415) 424-1114). I'm no Wall Street analyst, but my programmer's instinct tells me it's a winner. ■

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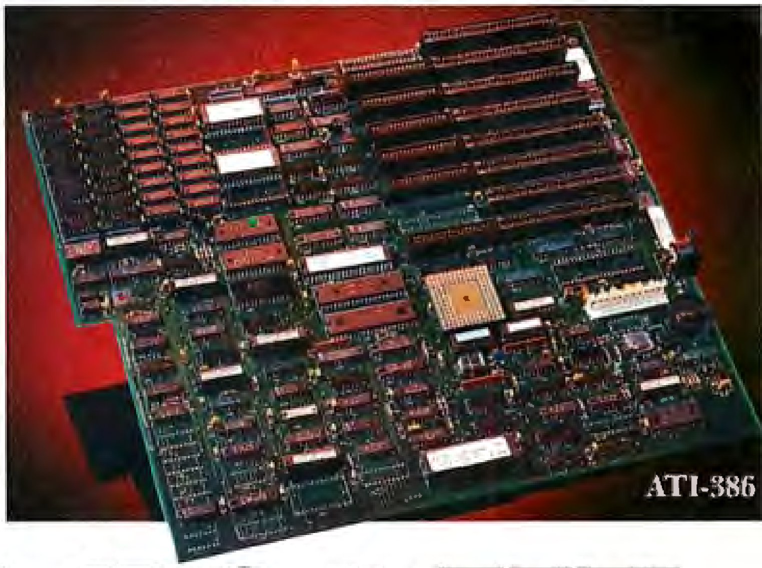

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9 MHz FastCACHE-286	7.1	1.32	28 (7)*	$399
12 MHz FastCACHE-286	10.3	.93	22 (6)*	$599

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Steve Ciarcia

Part 2: Schematic

Build the Circuit Cellar AT Computer

Steve reveals the circuitry for his AT on a board

Last month, we took a close look at the structure of the IBM PC AT computer, and I introduced the highly integrated POACH (PC on a chip) set from ZyMOS that makes an AT on a board a feasible project. This month, you'll see that, aside from the choice of board layout and perhaps memory configuration, the task is done. [Editor's note: *You'll want to keep last month's article on hand. Many AT circuit details Steve talks about this month were described there.*] Since most functions are already part of the POACH set, the remaining circuitry must follow strict guidelines to remain 100 percent compatible. In essence, the rest of the design is just "cookbook" stuff and—as you can see from the circuit schematic for CCAT in figure 1—is fairly simple.

Inside CCAT

The CCAT is designed to run with either an 8- or 10-megahertz system clock, depending upon which 80286 chip is used (−8 or −10). POACH1 generates both PROCCLK and the system clock (SYSCLK) from a 16- or 20-MHz crystal connected across pins 26 and 27.

POACH1 requires a 32.768-kilohertz time base (CCROSC) for the 6818 clock/calendar/RAM. A CMOS 74HC04 inverter is used as the oscillator amplifier. The POACH1 6818 requires only 10 microamperes of standby current. Battery power for the 6818 is connected to pin 32 of POACH1.

The local data bus (D0 through D15) runs between the 80286, 80287, and POACH3-D. Local address lines A1 through A23 go directly to POACH3-A, but since the POACH2 memory mapper also generates A17 through A23 during direct-memory-access operations, those address lines are also connected to POACH2.

The system address bus lines SA1 through SA19 are generated by POACH3-A. Normally, CPUHLDA and ALE control system bus activity. +ACK from POACH2 gates SA17 through SA19 during DMA operations. SA0 is generated directly from A0 by POACH1. POACH1 also produces +CNTL OFF, XA0, LSDOE, MSDOE, and DT/R, which are required gate and direction control for the system data bus.

Memory-address and data-bus generation is a convoluted affair if you try to handle it with discrete logic, but it becomes straightforward for the CCAT project. POACH3-A generates the multiplexed MA0 through MA8 address lines that are controlled by +REFRESH and GA-2RAS. The memory data bus (MD0 through MD15) connects POACH3-D directly to the dynamic RAMs and ROM. XA0 gates the least significant byte; XBHE gates the most significant byte. -XMEMR and DIRMS control direction; when both signals are high, data flow is from memory to system.

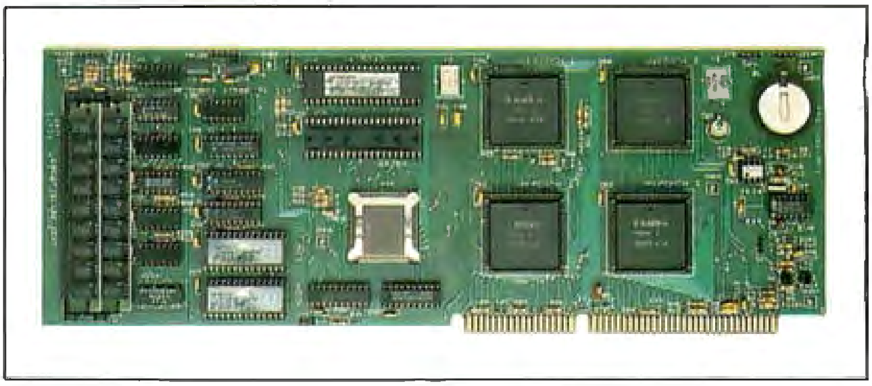
Primarily, the X address bus runs between POACH2, POACH3-A, and ROM. POACH2 generates -DMAAEN, which POACH3-A uses to control direction on the X bus during DMA operations. X data flows between POACH1, POACH2, the 8742 keyboard processor, and POACH3-D. DIR245 and -RDXDB control direction on the bus, and GATE245 and +ACK gate control the data flow.

The overall effect of integration on the AT is obvious when you view design complexity (including chip count) and board space. But some very subtle benefits don't immediately come to mind.

For instance, EMI (electromagnetic interference) and RFI (radio frequency interference) decrease dramatically. Every trace running across the circuit board is an antenna that radiates more ef-

continued

Photo 1: *The Circuit Cellar AT computer: an AT clone on a board.*



Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P.O. Box 582, Glastonbury, CT 06033.

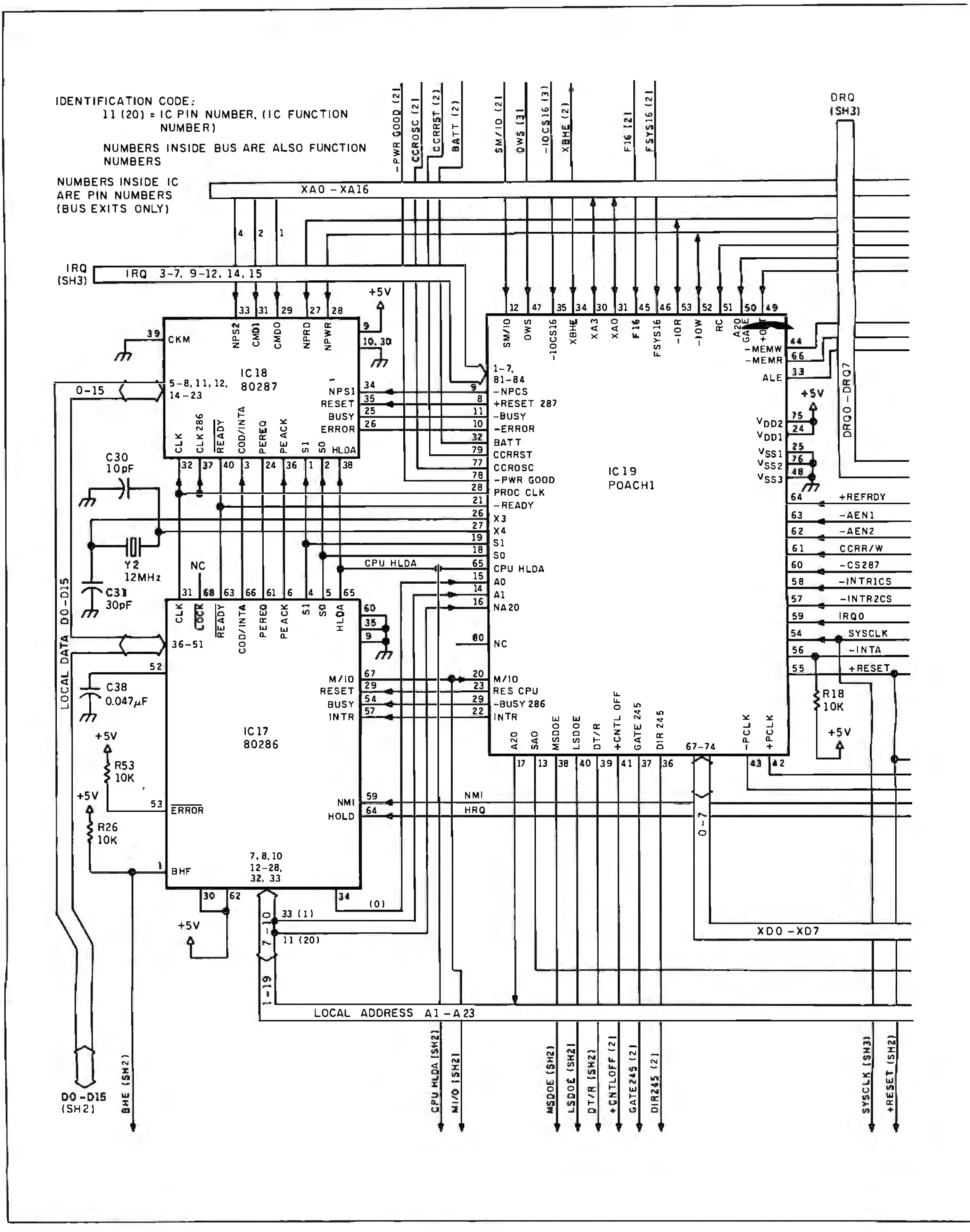
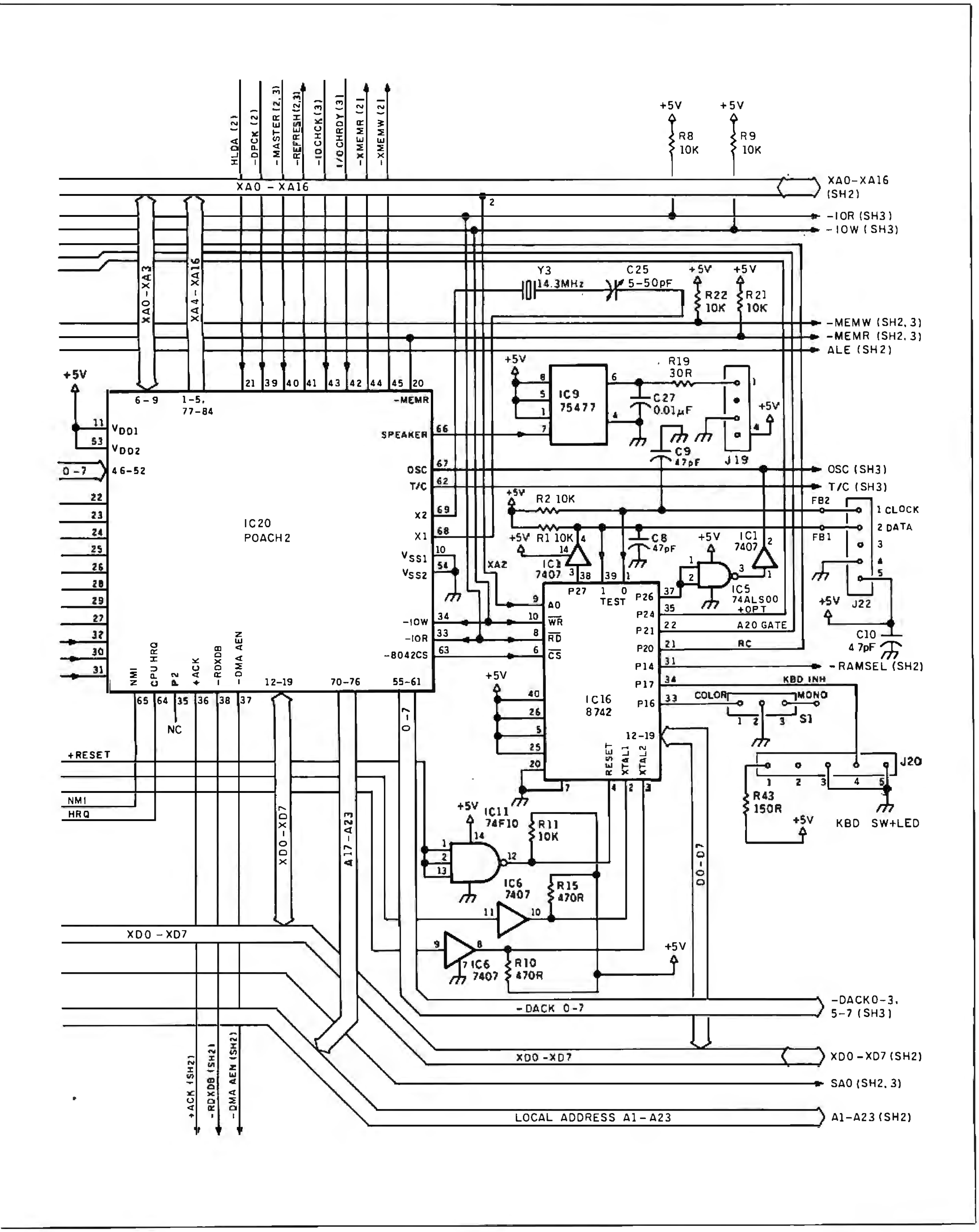


Figure 1: *The CCAT circuit schematic.*


HLDA (2)
-DPCK (2)
-MASTER (2,3)
-REFRESH (2,3)
-IOCHCK (3)
I/OCHRDY (3)
-XMEMR (2)
-XMEMW (2)
XA0 - XA16
XA0-XA16 (SH2)
-IOR (SH3)
-IOW (SH3)
+5V
R8 10K
R9 10K
Y3 14.3MHz
C25 5-50pF
R22 10K
R21 10K
-MEMW (SH2, 3)
-MEMR (SH2, 3)
ALE (SH2)
XA0-XA3
XA4-XA16
IC9 75477
R19 30R
C27 0.01μF
C9 47pF
J19
OSC (SH3)
T/C (SH3)
R2 10K
R1 10K
C8 47pF
IC1 7407
FB2
FB1
1 CLOCK
2 DATA
J22
C10 4.7pF
IC5 74ALS00 +OPT
A20 GATE
RC
-RAMSEL (SH2)
KBD INH
COLOR
MONO
S1
J20
R43 150R
KBD SW+LED
IC20 POACH2
VDD1
VDD2
-MEMR
SPEAKER
OSC
T/C
X2
X1
VSS1
VSS2
-IOW
-IOR
-8042CS
NMI
CPU HRQ
P2
+ACK
-RDXDB
-DMA AEN
NC
+RESET
NMI
HRQ
IC16 8742
TEST
RESET
XTAL1
XTAL2
IC11 74F10
R11 10K
IC6 7407
R15 470R
R10 470R
XD0-XD7
A17-A23
D0-D7
-DACK 0-7
-DACK0-3, 5-7 (SH3)
XD0-XD7 (SH2)
SA0 (SH2, 3)
LOCAL ADDRESS A1-A23
A1-A23 (SH2)
+ACK (SH2)
-RDXDB (SH2)
-DMA AEN (SH2)

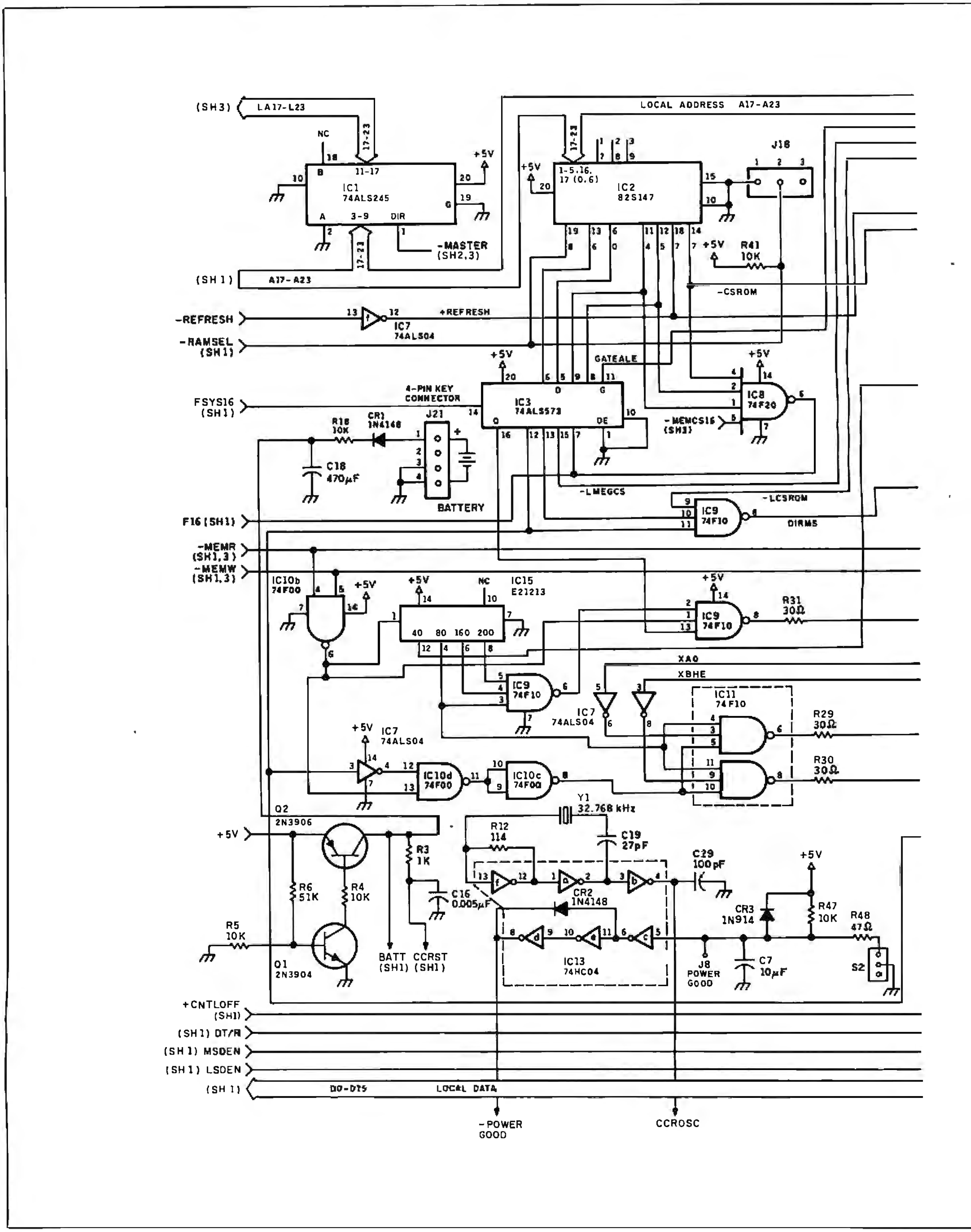
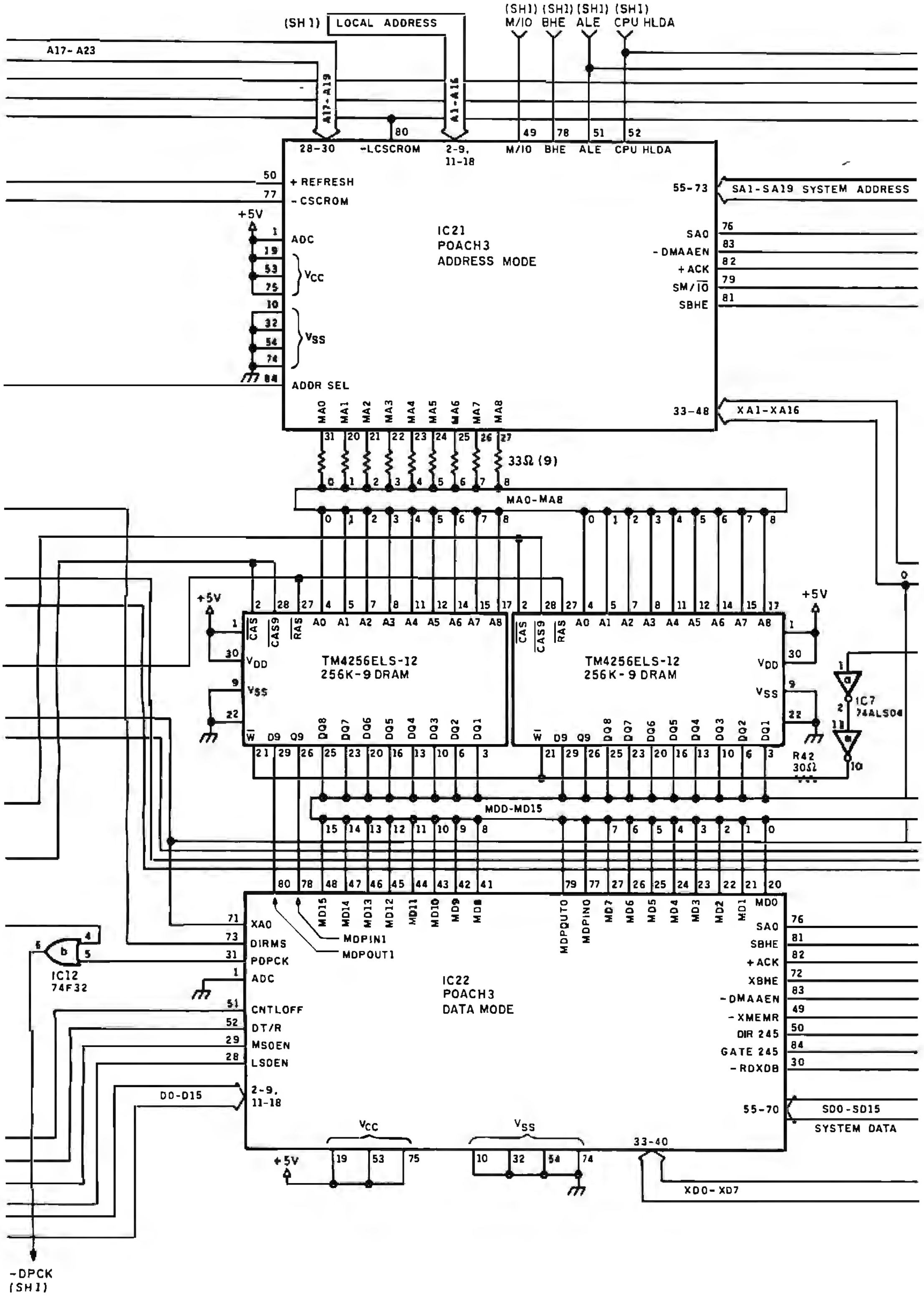


Figure 1: *Continued.*


(SH 1) LOCAL ADDRESS
(SH1) M/IO
(SH1) BHE
(SH1) ALE
(SH1) CPU HLDA
A17- A23
A17-A19
A1-A16
28-30
-LCSCROM
2-9, 11-18
M/IO BHE ALE CPU HLDA
+ REFRESH
- CSCROM
+5V
ADC
VCC
VSS
ADDR SEL
IC21
POACH3
ADDRESS MODE
55-73
SA1-SA19 SYSTEM ADDRESS
SA0
- DMAAEN
+ ACK
SM/IO
SBHE
33-48
XA1-XA16
MA0 MA1 MA2 MA3 MA4 MA5 MA6 MA7 MA8
33Ω (9)
MA0-MA8
+5V
CAS CAS9 RAS A0 A1 A2 A3 A4 A5 A6 A7 A8
VDD
VSS
TM4256ELS-12
256K-9 DRAM
W D9 Q9 DQ8 DQ7 DQ6 DQ5 DQ4 DQ3 DQ2 DQ1
TM4256ELS-12
256K-9 DRAM
IC7
74ALS04
R42
30Ω
MDD-MD15
MD15 MD14 MD13 MD12 MD11 MD10 MD9 MD8
MDPIN1
MDPOUT1
MDPOUT0 MDPIN0 MD7 MD6 MD5 MD4 MD3 MD2 MD1 MD0
XA0
DIRMS
PDPCK
ADC
CNTLOFF
DT/R
MSOEN
LSDEN
2-9, 11-18
D0-D15
IC12
74F32
IC22
POACH3
DATA MODE
SA0
SBHE
+ ACK
XBHE
- DMAAEN
- XMEMR
DIR 245
GATE 245
- RDXDB
55-70
SD0-SD15
SYSTEM DATA
VCC
VSS
+5V
33-40
XD0- XD7
-DPCK
(SH1)

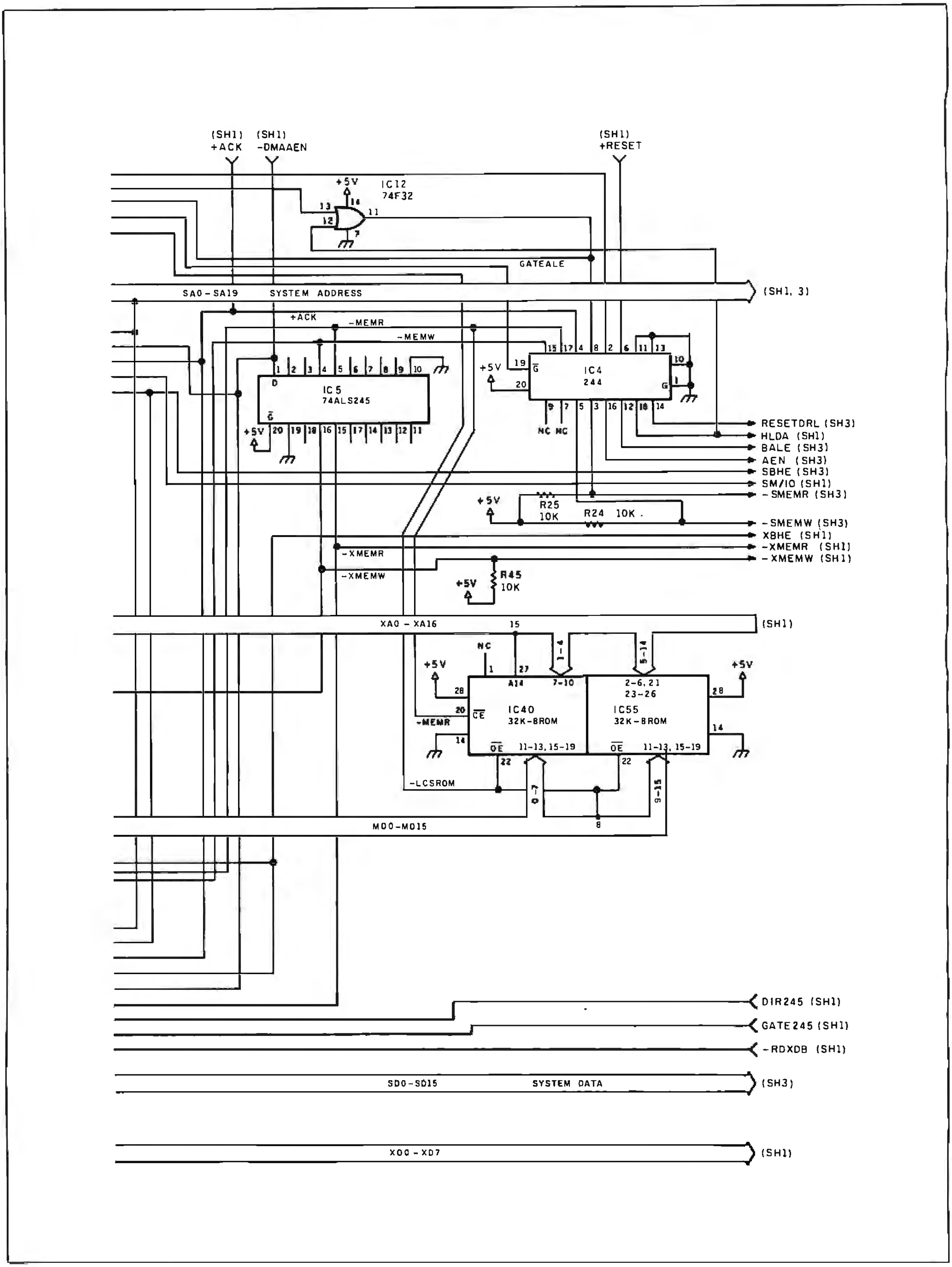


Figure 1: *Continued.*

fectively as the length increases, particularly if it becomes tuned to the carrying frequency. Integration collapses trace lengths, subsequently reducing emissions. Also, since the POACH set is CMOS, power requirements are substantially reduced. The original IBM PC AT motherboard drained 5 amperes. The CCAT requires less than 1 A (typically, about 0.8) at 5 volts.

The final configuration agreed upon for the CCAT was a six-layer printed circuit board with an AT expansion-board form factor: 4.8 inches high by 13.12 inches long (see photo 1). The four 84-pin packages in the center right portion of the board are the POACH chips. To their left are the three processors in the system: the 8742 keyboard controller, the 80287 math coprocessor, and the 80286 16-bit microprocessor. The Award Software ROM BIOS is located in the two sockets on the lower left portion of the board, labeled Low and High for low byte and high byte, respectively. The 16-MHz crystal, which provides clocking for the whole system, lies between the 8742 and POACH1.

Power, ground, system-address, data, and control signals are available at the edge connectors (see figure 2). These edge connectors follow the standard pinout of the IBM PC AT bus. The speaker and external backup-battery connections are located on the upper right edge of the card, immediately above the on-board battery. Both are 4-pin Berg strips with pin assignments, as shown in table 1.

A hardware clone of an AT is not considered compatible unless its operating system and application software also function in a manner equivalent to the way they would on an IBM PC AT. This compatibility is facilitated through the ROM and keyboard-controller BIOSes provided by Award Software for the CCAT. This licensed software is among the most efficient available to IBM PC-compatible developers.

One handy feature of the Award BIOS on the CCAT is that the Setup program usually provided on disk is built into the ROM. Invoking the Ctrl-Alt-Esc key sequence enters Setup where you can set the following options: date, time, diskette1, diskette2, disk1, disk2, video, base memory, extended memory, and error halt.

Putting the CCAT to Use

Even though it might be obvious at this point, I want to emphasize that the CCAT is the equivalent of the IBM PC AT motherboard. Like any AT motherboard, it needs other peripheral cards to function as a computer system. To create a system, you plug the CCAT and all the peripheral cards into a passive backplane (often called a passive motherboard) that carries all the signals from the CCAT to the other peripheral cards. (A passive backplane contains no circuitry—only connectors and connecting wires.)

Neglecting some of the new super-multifunction boards, a minimum CCAT system would require a display-driver card (e.g., EGA, CGA, and monochrome), an AT floppy disk or AT floppy/hard disk controller card, and a keyboard. For a complete system, you would add one more combo card containing memory expansion and serial and parallel ports. Thus, a full-function CCAT computer is made up of four cards. Visualize four expansion cards plugged into your present XT or AT, and you will see that it takes relatively little volume. That giant motherboard and power supply were hogging all the space!

I've already stated that the CCAT is both smaller and more power-efficient than a standard AT configuration. Being more efficient, it needs no power-supply fan or monster power supply (power requirements beyond the CCAT, of course, depend upon the specific peripherals you plan to use). Newly introduced VLSI display and disk-controller cards are also more energy-efficient as well.

In Conclusion

While the greatest audience for the CCAT design will eventually be OEMs looking for a better 80286-based computer, such testaments are relatively boring to an end user reading this article. Instead, to provide a suitable demonstration, it was only natural for me to consider making a briefcase-size, battery-operated portable computer as the conclusion to this project.

The CCAT is both smaller and more power-efficient than a standard IBM PC AT configuration. It needs no power-supply fan or monster power supply.

Unfortunately, like most computer systems these days, objective is not necessarily reality. I briefly considered building something to rival one of the commercially produced portable computers, but that was like trying to fit 10 pounds in a 5-pound bag. The CCAT does indeed reduce the size of the AT electronics to a point where such a project is conceivable, but standard form-factor peripheral cards, disk drives, batteries, a

continued

Table 1: *Speaker and external backup-battery pin connections.*

Pin	Speaker	Battery
1	Data out	Ground
2	Key	Not used
3	Ground	Not used
4	+5 V DC	6 V DC

Photo 2: *CCAT in a box.*

With the CCAT board, the only task becomes that of mechanically fitting off-the-shelf peripheral hardware in the smallest box.

display, and an AT keyboard just wouldn't fit in a briefcase.

Short of redesigning everything and making this portable computer a bigger project than the CCAT, I had to resort to using a larger case. Fortunately, I had this nice camcorder case sitting around holding an infrequently used camcorder. Out went the camcorder, and in went the CCAT and a bunch of other junk. Ten pounds eventually evolved into 30 pounds, with my minimal but efficient configuration losing out to enclosing everything but the kitchen sink. Equipment cases are like mass storage—the more room you have, the faster it seems to be filled.

My CCAT portable uses a backlit LCD, as most portables do. This $1395 display from Axonix Corp. (2257 South 1100 East, Suite 2C, Salt Lake City, UT 84106) has 640- by 200-pixel resolution and connects to the RGB output of a CGA display card, making it suitable for homebrew applications.

This display—and everything else in the unit—is powered from a pair of 4-A-hr 12-V gel-cel batteries (read that as *heavy*). The 12-V battery output is also converted to +5 V for the computer section and −12 V for RS-232.

The brain is a four-card AT system mounted on its side to reduce space. It consists of the CCAT board, a standard AT-style keyboard, an IBM CGA board, and clones of standard AT floppy/hard disk controllers and AST SixPakPlus expansion boards. Since we didn't know any better and nobody lifted the case until we finished, we added both a half-height floppy disk drive and a 40-megabyte hard disk drive.

There is nothing more I can add about this portable, beyond telling you what is in the case. With the CCAT board, the only task becomes that of mechanically fitting all this off-the-shelf peripheral hardware in the smallest box. We succeeded, and it works well indeed (see photo 2).

It operates for about 2 hours on the internal batteries, but it is better to plug it in the wall with the rest of the computers. And, while technically portable, it is a bit too large to use on your lap in an airplane. Still, it serves well as a transportable, and these 8088 portables are put to shame when you turn on the switch and crank up the CCAT's 10-MHz 80286.

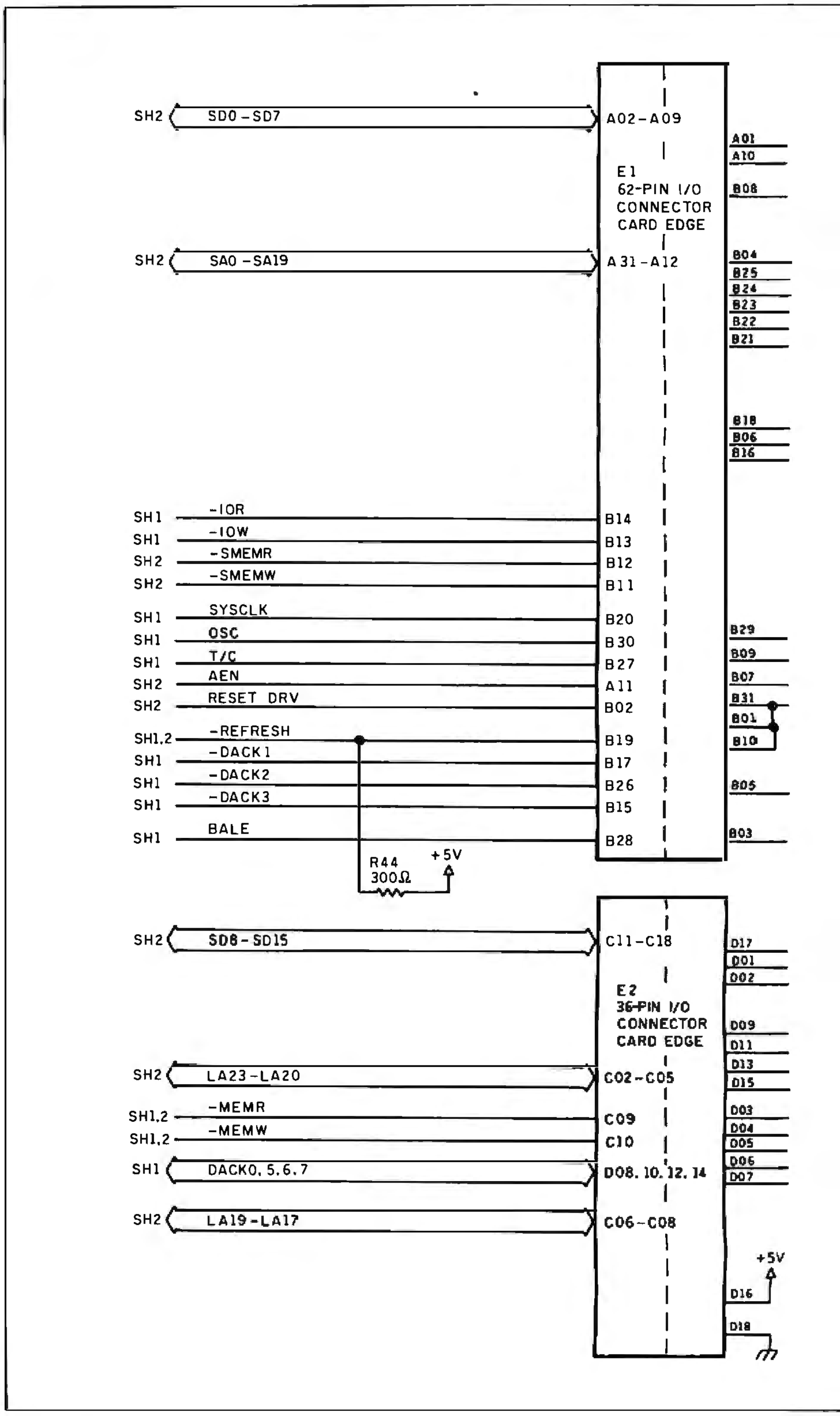
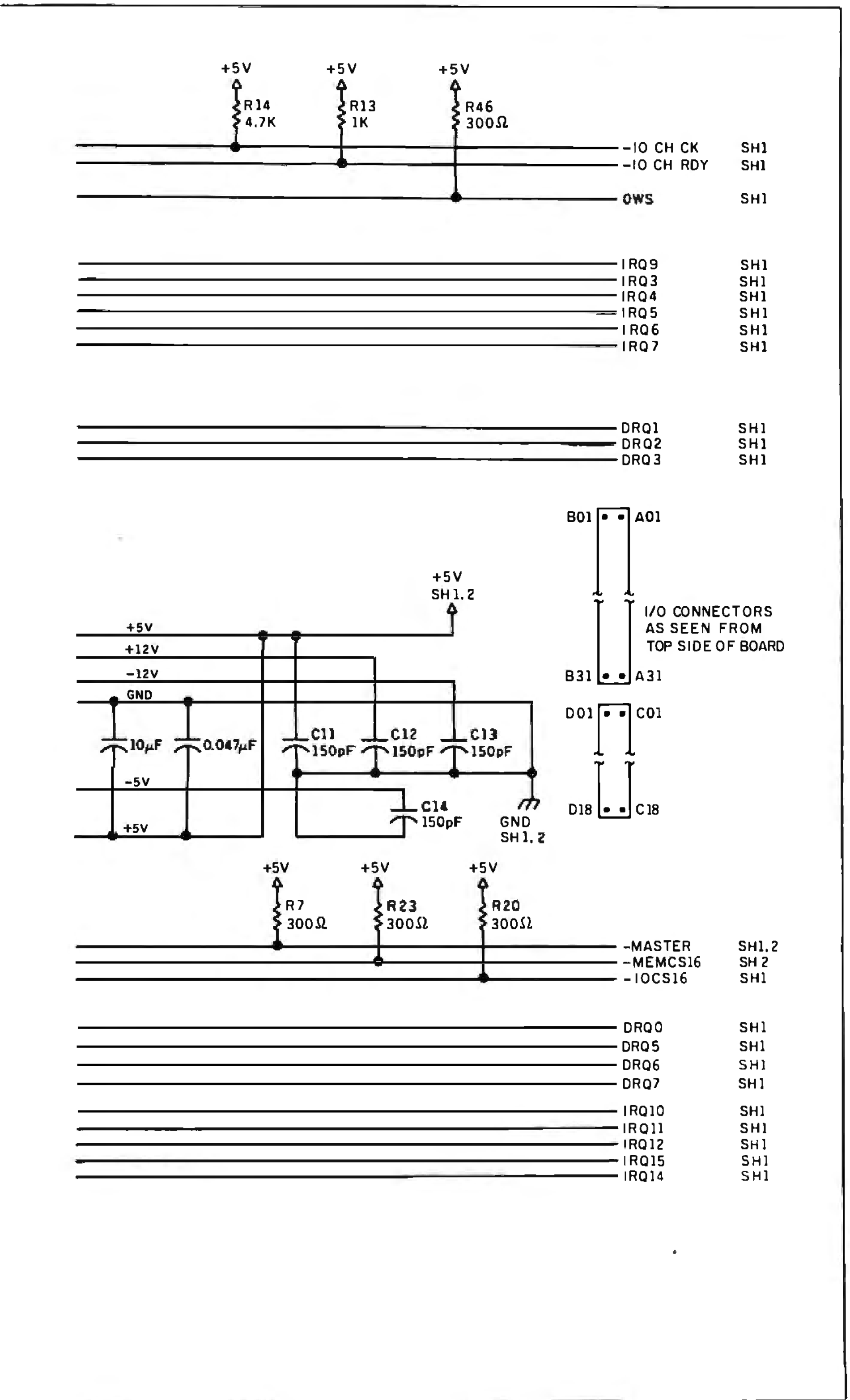


Figure 2: *Edge-connector pin-outs for the CCAT.*

Next Month

I'll begin a two-part project on how to build an IC tester. ■

The CCAT was a joint venture, and I'd like to note the contributions and help



from ZyMOS, Micromint, Award Software, and the Circuit Cellar research staff. In addition, I'd like to personally thank Bob Andrews, Jeff Bachiochi, Jeff Remmers, Steve Smith, and Charles Skyles for their efforts.

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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   order CCAT/DEV........................$475
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POACH chips and BIOS ROMs are available. Call for price and delivery information.

For either source above, all payments should be made in U.S. dollars by check, money order, MasterCard, Visa, or American Express. Surface delivery (U.S. and Canada only): add $5 for U.S., $8 for Canada. For delivery to Europe via U.S. airmail, add $14. Three-day air freight delivery: add $10 for U.S. (UPS Blue), $25 for Canada (Purolator overnight), $45 for Europe (Federal Express), or $60 for Asia and elsewhere in the world (Federal Express).

There is an on-line Circuit Cellar bulletin board system that supports past and present projects. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300/1200/2400-bps BBS is on-line 24 hours a day at (203) 871-1988.

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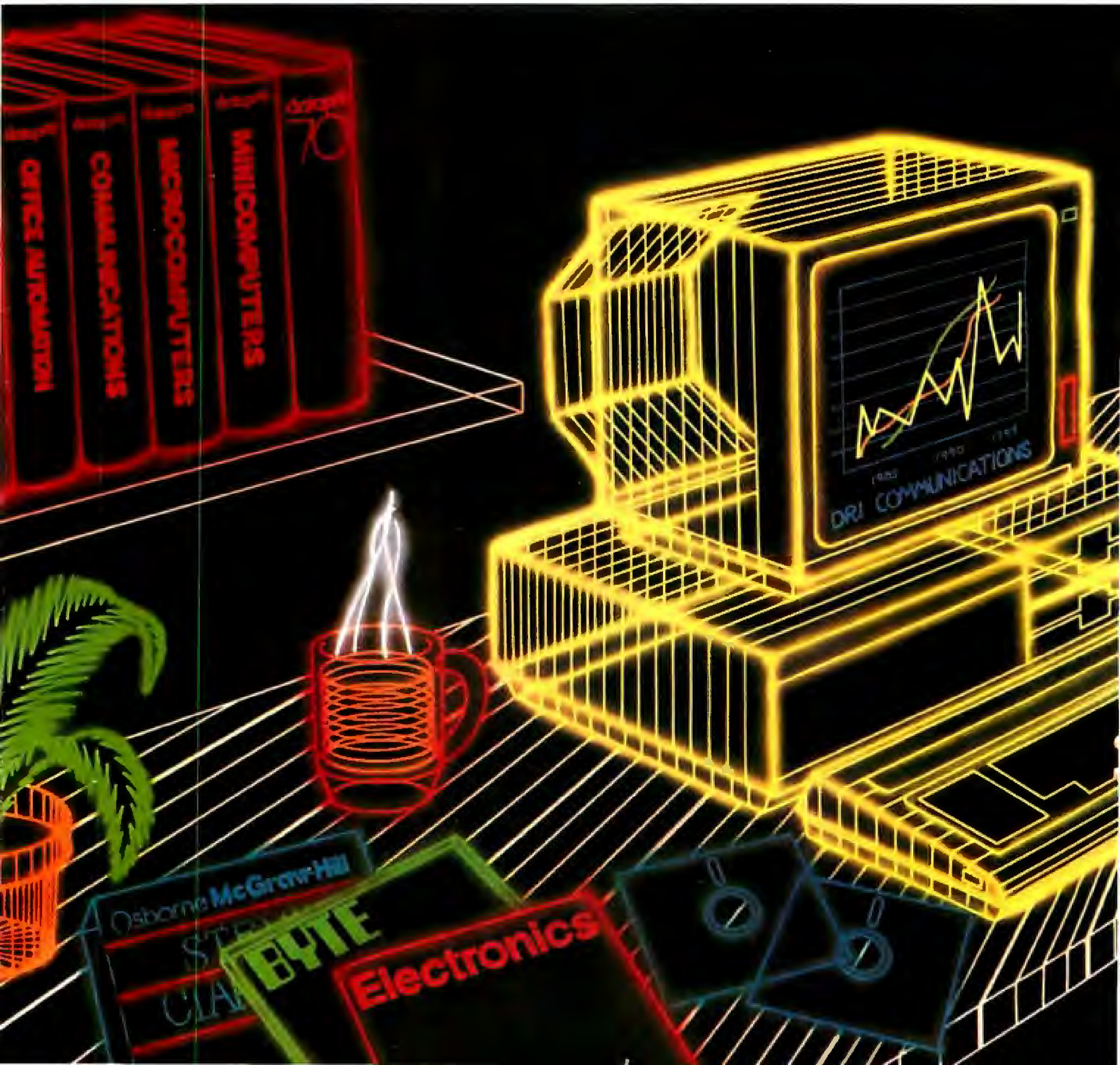

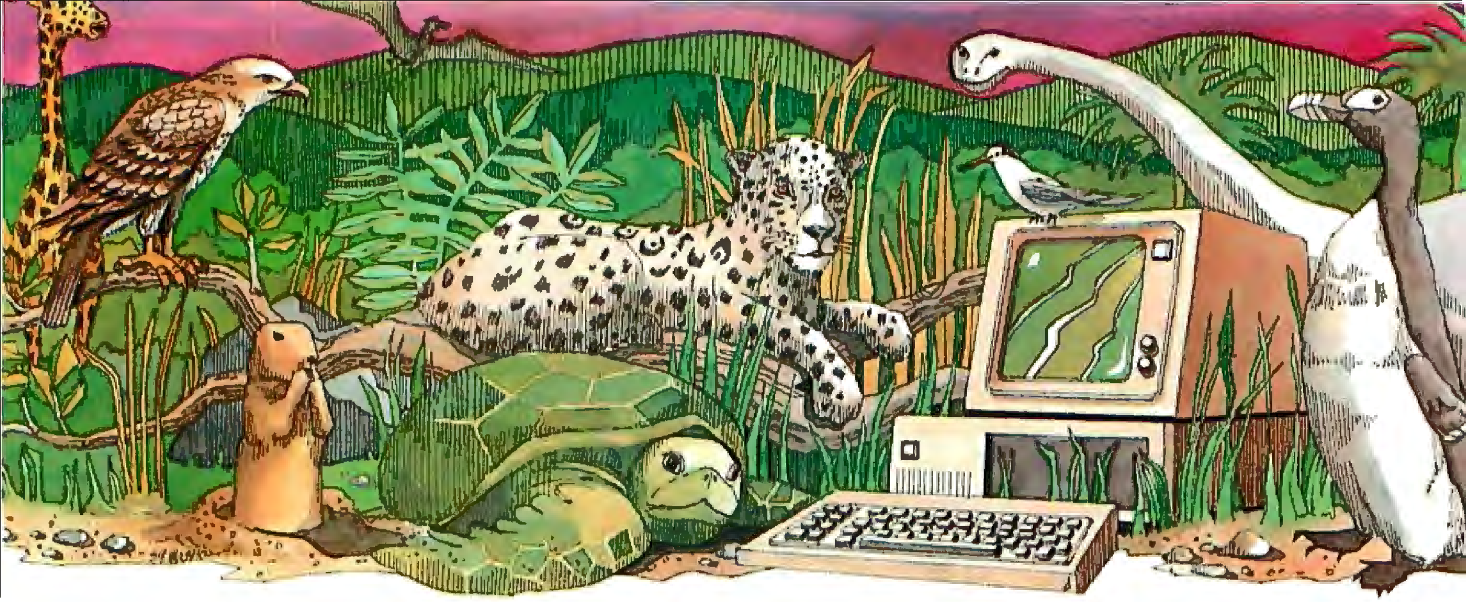

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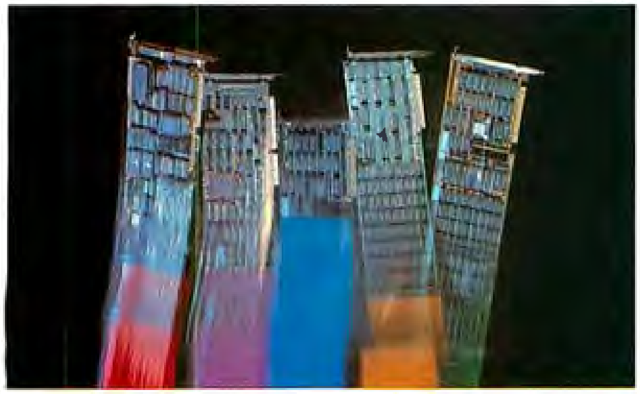

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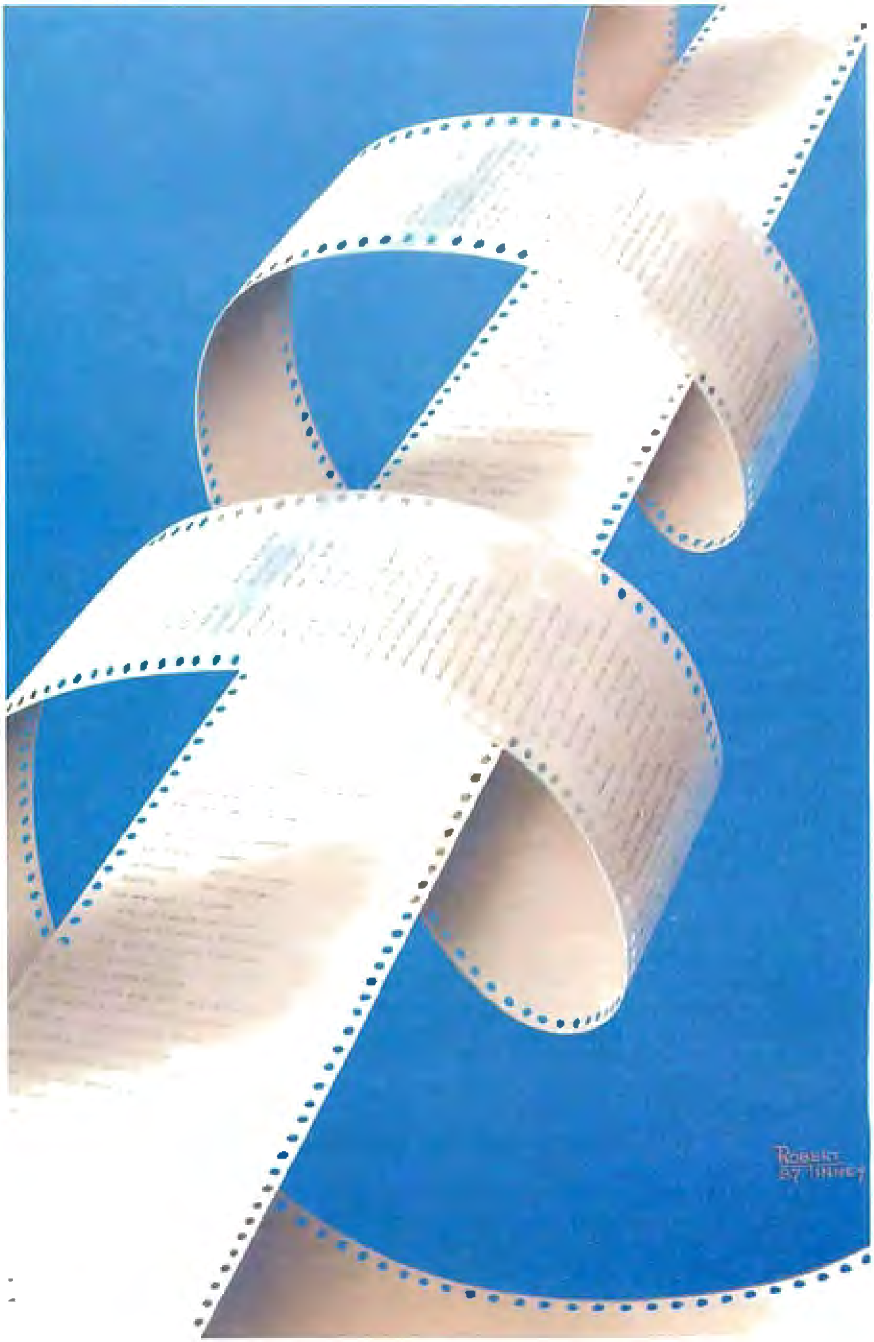
Heuristic Algorithms



Introduction

Heuristic Algorithms

No matter how good a given algorithm is, it can't deal with problems it wasn't designed to solve, nor can it handle subtle variations of a problem. An algorithm, unfortunately, can only provide solutions to specific problems.

Heuristics can provide the capability to deal with the subtle variations in a problem, or to deal with a totally new problem, by devising a solution based on previous experience.

The synergy of these dissimilar methods of problem solving can provide powerful new tools to practitioners of artificial intelligence. A marriage of heuristic learning and algorithmic problem solving has already appeared in commercially available expert systems.

Heuristic algorithms have many potential applications. For example, computerized systems to design and control the manufacturing process, such as expert systems and other optimization systems, are becoming widespread. The problems solved by such systems (scheduling jobs, laying out workpieces, routing robots) are very often optimization problems of a combinatorial nature. Because these problems can be computationally very expensive to solve exactly, and because a solution must often be found in a real-time environment, heuristic rather than exact-solution techniques are frequently used.

One goal of ongoing research at Stanford University is to investigate methods for evaluating heuristic solutions to large-scale manufacturing problems. There are several combinatorially difficult manufacturing problems, including parts nesting, cutting-path determination, and machine scheduling. Since these types of problems are typically solved by a computer in real time, the "learning" power of a computer can be applied in a dynamic manufacturing environment.

In the following pages, we explore the emergence of some heuristic algorithms.

One of the most promising applications of machine learning to problem solving is in the embryonic field of neural networks. Neural networks were first conceived in the 1950s, but only lately have researchers successfully achieved results simulating these networks.

Two articles in this issue explore neural-network heuristic algorithms. Gary Josin gives an overview of general approaches to the heuristics of neural networks. William P. Jones and Josiah Hoskins closely examine the delta learning rule with back-propagation and offer a C-language program that demonstrates the technique.

Beyond neural networks, Paul V. Haley writes about the need for heuristic techniques in developing algorithms in Prolog. Haley explains the ways in which Prolog needs to be modified to permit *best-first*, instead of *depth-first*, searches.

Optimization problems constitute a category rich for the potential application of heuristic algorithms. Of particular interest is compiler optimization. Mark Roberts looks at this subject and speculates on the promise of heuristics in the development of microcomputer optimizing compilers.

The zero-knowledge-proof algorithm, developed recently by researchers at MIT; Berkeley; Haifa, Israel; and Toronto, uses a heuristic technique that Peter Wayner illustrates with a BASIC program.

Finally, we conclude our exploration of heuristic algorithms with Leon Sterling's examination of an equation solver written in Prolog that emulates the problem-solving heuristics of math students.

Although we may have only scratched the surface of this intriguing subject, we hope we've suggested the potential of the synthesis of heuristics and algorithms.

—G. Michael Vose, Senior Technical Editor

Zero-Knowledge Proofs

A new heuristic method lets you prove your identity without revealing a password or other information

Peter Wayner

RECOGNIZING THE DIFFERENCE between an authorized user and a fake is a difficult problems for computers. Traditional password systems and other heuristics for controlling access can never be made perfectly secure because a computer can judge only the signals it receives, not whether the binary bits are the product of a sincere, authorized user or of an impostor providing the same input.

Now, new mathematical techniques known as zero-knowledge proofs can strengthen these heuristic approaches by providing complex *interactive passwords* for users, passwords that cannot be faked by anyone who happens to intercept the message—or even by the host computer itself. The chief developers of the new methods are Oded Goldreich of Haifa University, Silvio Micali and Shafi Goldwasser of MIT, Manuel Blum of Berkeley, Charles Rackoff of the University of Toronto, and others (see reference 1).

Zero-knowledge proofs differ from regular mathematical proofs in two epistemologically curious ways: They hide the truth while defending its validity, and they are played out much like a card game. In a zero-knowledge-based exchange, the prover first makes an assertion. The skeptic verifies the assertion and specifies the next fact he or she would like to hear. The prover responds with another assertion. The exchange continues until the skeptic is satisfied.

What makes this ordinary-sounding interrogation process unique is that the individual assertions taken together reveal no privileged information *except* the fact that the prover isn't lying; the skeptic can safely conclude that the prover is indeed the person he or she claims to be.

A Preliminary Example

Arms-control treaties, because they are plagued by mistrust, are a good preliminary example for understanding how an interaction can hide information while providing some kind of validation.

Suppose a nation wants to prove it does not have nuclear warheads at a storage plant without revealing exactly how many conventional warheads it has stockpiled. In one zero-knowledge approach, the representative from the proving nation randomly divides the warheads between two locked rooms. The examiner from the skeptical nation flips a coin to choose one of the rooms. The prover hands the skeptic the corresponding key so he can check the contents of the selected room. If the skeptic doesn't find a nuclear warhead in the room, he can conclude there is only a one-in-two chance that the treaty is being violated.

The prover nation locks both doors, rearranges the warheads, and again lets the skeptic nation randomly select a room for viewing. After this examination, if no nuclear weapons are found, the skeptic concludes there is only a one-in-four chance that the treaty is being violated.

After 20 or 30 such iterations, the skeptic can be satisfied that even though he lacks absolute proof, the chance that he has chosen the wrong door every time is practically nil. Meanwhile, the prover can be content that the exact number of missiles hasn't been revealed.

This isn't a true zero-knowledge proof because it gives the skeptic a statistically converging estimate of the number of missiles. Nevertheless, it does illustrate several important facets of the method.

First, the techniques never prove something perfectly and incontrovertibly, but they always come as close as the two parties' patience will allow. This is a drawback for anyone who needs literal certification, but it should make no difference to practical people who realize how quickly 2^n shrinks. Second, zero-knowledge proofs keep the prover honest by letting the skeptic demand any particular fact, while hiding the entire truth from the skeptic by letting him or her choose only a fraction at most. Third, these proofs rely upon one-way functions to protect the information.

One-way functions are an important part of cryptography, enabling a person to encrypt information and place it in the open, secure in the knowledge that no inverse function can be found to decipher the information. In the warheads example, the one-way function is the random division of warheads between the two rooms. It is impossible to infer the total number of warheads from the number found in just one of the rooms.

In mathematics, one-way functions are operations that have no inverse, or at least no readily discoverable inverse. For in-

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The security can be further strengthened by requiring that each prover be able to handle any of 1000 different x,y pairs.

stance, given a list of prime numbers, you can easily generate a product. However, the inverse operation—factoring—can be so time-consuming as to be impractical when the number is large—say, 100 or more digits. The public-key-cryptography system (see reference 2) relies on the difficulty of factoring large numbers.

Quadratic residuosity is another number-theoretic property that gives a good one-way function (see reference 3). I will use it in a program that demonstrates the operation of a zero-knowledge proof.

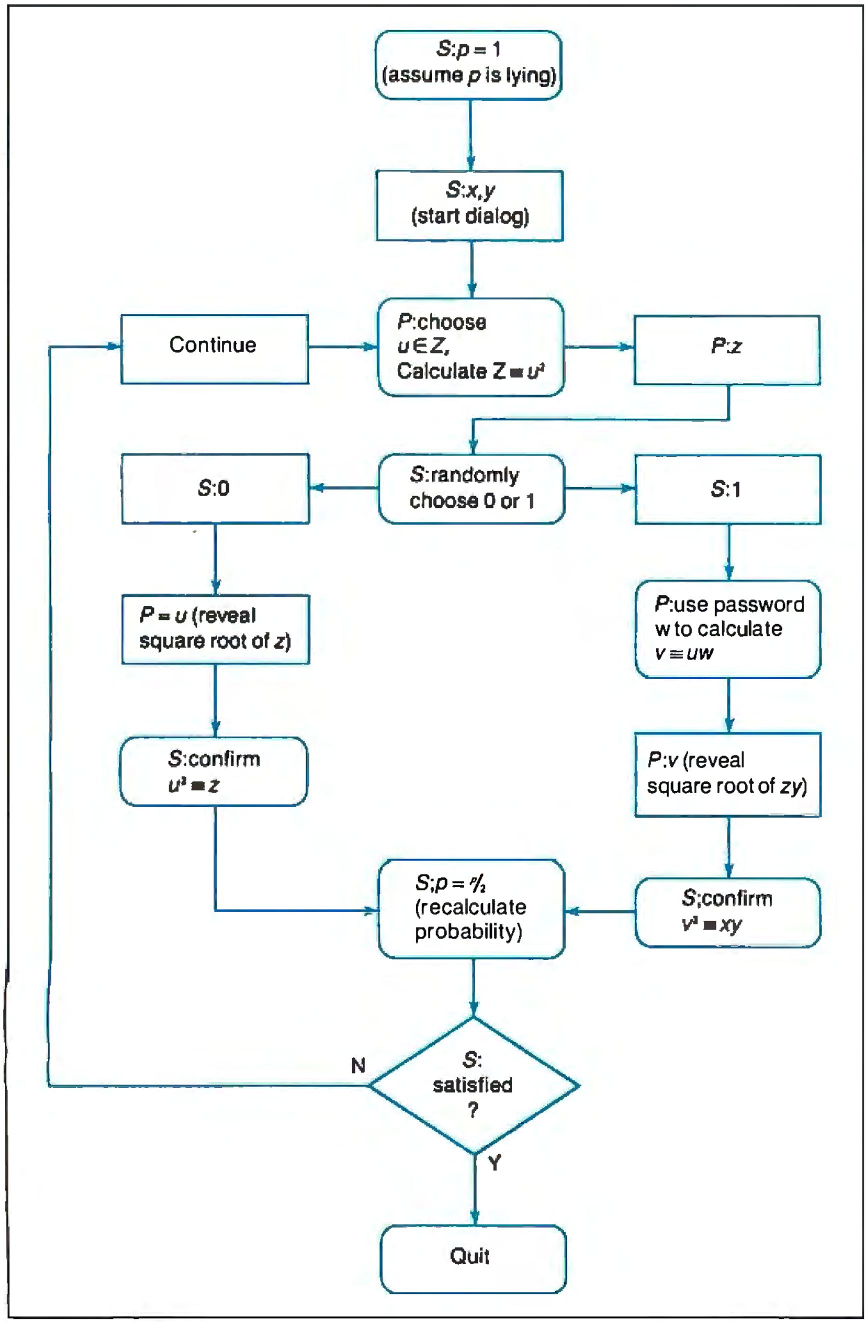

Figure 1: *Flow diagram of a zero-knowledge dialog between skeptic S and prover P. Squares indicate data revealed over the communications link; circles represent internal processing.*

First, we need some theoretical background.

Quadratic Residues

Given y relatively prime to x (i.e., x and y have no common factors except 1), y is said to be a quadratic residue of x if there exists a w such that $w^2 \bmod x = y$. For example, 9 and 10 are relatively prime, and $7^2 = 49 \bmod 10 = 9$, so 9 is a quadratic residue of 10.

For shorthand, let Z_x symbolize the set of integers relatively prime to x and QR_x symbolize the set of all elements in Z_x that are quadratic residues of x. For instance, $Z_{10} = \{1, 3, 7, 9\}$ and $QR_{10} = \{1,9\}$ since only those two numbers have square roots in Z_{10}: $1 = 1^2 \bmod 10 = 9^2 \bmod 10$, and $9 = 3^2 \bmod 10 = 7^2 \bmod 10$.

Quadratic residuosity makes a good one-way function because it is easy to square a number modulo x but difficult to find the square root of a number modulo x when the number is relatively prime to x and the factors of x are unknown.

Three other properties of quadratic residues are important here. First, the fastest way known to compute whether y is a quadratic residue of x is to start by factoring x into primes. Since this is hard when x is the product of large prime numbers (in excess of 100 digits each), a strong system must start with a very large x. The zero-knowledge interaction will also reveal nothing about the factors of x. Second, every $y \in QR_x$ has an equal number of square roots w such that $w^2 \bmod x = y$. The third property concerns products of two integers. If $y,z \in QR_x$ then $yz \in QR_x$; if $y \in QR_x$ but $z \in Z_x - QR_x$ then $yz \in Z_x - QR_x$. These facts can be proved using group theory or at least verified by working through a few sample cases.

A Working Example

In the working example, the prover is given x and y and asked to prove that y is a quadratic residue without revealing its square root. The square root is, in effect, the password, and the zero-knowledge techniques let the prover keep the password secret from the skeptic while still showing that he knows it. This prevents the password from being stolen by an eavesdropper.

Here is a more detailed view of the protocol. Keep in mind that all computations are done modulo x even when not explicitly so stated.

The skeptic S starts by giving the prover P the number pair (x,y). P will prove that he knows a square root w (i.e., $w^2 \bmod x = y$) without revealing what it is. P randomly selects u, a member of Z_x, squares it, and sends the result $z = u^2 \bmod x$ to S.

S then sends P a random bit, 0 or 1. If the bit is 0, P must reply with u, and S confirms that u is indeed a square root of the first number z. If the bit is 1, P uses the secret value w to form the product $v = uw \bmod x$, which he sends to S. S checks that this value is indeed a square root of the product zy. (Remember, $z = u^2$ and $y = w^2$ so $zy = u^2w^2 = vy$.)

In either case, P's correct response convinces S with a probability of ½ that P does know a square root of y. The process is repeated until the probability of cheating grows small enough to satisfy S. Figure 1 diagrams the process.

The technique works because it is not possible for both u^2 and u^2y to have square roots unless y is a member of QR_x. Since P doesn't know which he will be asked to provide ($\sqrt{u^2}$ or $\sqrt{u^2y}$), he cannot try to fake the choice of u. However, since P reveals only u or uw, it is impossible for S (or an eavesdropper) to derive a square root w of y from the information provided. Without a w, it is impossible to calculate a square root of u^2y, as required to satisfy S.

The BASIC program in listing 1 implements this system for the sake of demonstration. Both parties to the dialog are handled in separate routines of the program. The main program sets x and y, and then calls the two routines in turn using global variables to pass values between the two. A short routine, based on Euclid's algorithm, is used by both subroutines to test relative primality.

Several considerations are important to build a strong system. The first is making sure that x is large enough and has at most two factors (other than 1) of equal length. If x is prime, then the size of QR_x is $(x-1)/2$. If x is the product of primes p_1 and p_2, then QR_x has $((p_1-1)/2)((p_2-1)/2)$. (This can be proven with group theory.) Since every $y \in QR_x$ has the same number of square roots, it follows that each has only two or four square roots. This reduces the possibility of finding a square root simply by guessing.

The security of this system can be further strengthened by requiring that each prover be able to handle any of, say, 1000 different x,y pairs. The skeptic computer chooses a pair at random, and the prover must prove (in the zero-knowledge sense) that y is a member of QR_x. Having 1000 possible sets of quadratic residues adds deterrence by increasing the computational burden on any would-be intruder.

Of course, there are caveats to the particular zero-knowledge method outlined in this article, using quadratic residues. Its security relies heavily on the assumption that factoring numbers is too difficult to be done in a reasonable amount of time. If the numbers are chosen incorrectly, the system is not strong enough. Alternatively, if computer technology or mathematical theory advances sufficiently to make factoring a fast process, the quadratic residues method (and many more of today's encryption systems) will be vulnerable.

Practical Uses

Zero-knowledge proofs require a great deal of computation and thus are probably not adaptable to situations that rely

continued

A short routine, based on Euclid's algorithm, is used by both subroutines to test relative primality.

Listing 1: *A BASIC program, written in QuickBASIC, demonstrating the zero-knowledge-proof method using quadratic residues. A sample run is given at the end of the listing.*

```
RANDOMIZE
x = 100
DIM qr(100)
'qr(i)=0 if i is relatively composite to x
'      =1 if i is relatively prime to x
'      =2 if i is relatively prime and is a quadratic residue
FOR i = 1 TO x
  qr(i)=1
NEXT i
loop1:
  'Mark the primes and composites
  FOR i=2 TO x
    j=i
    k=x
    again:
      IF j MOD k = 0 THEN
        qr(i) = 0
      ELSEIF j MOD k = 1 THEN
        qr(i) = 1
      ELSE
        jj=j
        j=k MOD j
        k=jj
        GOTO again
      END IF
  NEXT i
loop2:
  'Mark the quadratic residues
  FOR i=1 TO x
    IF qr(i)>0 AND qr((i*i) MOD x)>0 THEN qr((i*i) MOD x) = 2
  NEXT i
start:
  'Select a y at random
  w = INT(x*RND)
  'Make sure it is a quadratic residue
  IF qr(w)=0 THEN GOTO start
  y = (w*w) MOD x
  PRINT USING "Prover: (Secret password w = ###)";w
  PRINT
  PRINT USING "Skeptic: (x,y) = (### , ###)"; x,y
  'x and y are global variables
  'w is known only to the prover
  'z,b,u,v are the four numbers exchanged
  'between the prover and the skeptic
  prob = 1 'Initial probability that prover is lying
  FOR try=1 TO 10
    PRINT
    PRINT "Round: ";try
    prover1:
      'Set n1=w^2 MOD x and n2 = y*w^2 MOD x
      'Randomly select a u in Z(x)
```

continued

```
        u = INT(x*RND)
        IF qr(u)=0 THEN GOTO prover1
        z=(u*u) MOD x
        PRINT USING "Prover: z = ##";z
     skeptic1:
        'Sees z and asks for square root of z
        'or square root of zy
        b=int(2*RND) 'b = 0 or 1
        Print using "Skeptic: b = #";b
     prover2:
        'Returns the correct square root
        IF b=0 THEN
          PRINT USING "Prover: u = ##";u
        ELSE
          v = (u*w) MOD x
          PRINT USING "Prover: v = ##";v
          END IF
     skeptic2:
        'Checks the prover's response
        IF b=0 AND (u*u) MOD x = z THEN
          PRINT "Skeptic: (u*u) MOD x = z: Ok."
        ELSEIF b=1 AND (v*v) MOD x=(z*y) MOD x THEN
          PRINT "Skeptic: (v*v) MOD x = (z*y) MOD x: Ok."
        ELSE
          IF b=0 THEN
            PRINT "(u*u) MOD x <> z"
            STOP
          ELSE
            PRINT "(v*v) MOD x <> (z*y) MOD x="
            STOP
          END IF
        END IF
     'Compute probability of lying
     prob=prob*.5
     PRINT "Skeptic: Probability of lying = ";prob
   NEXT try

run
Random Number Seed (-32768 to 32767)? 55
Prover: (Secret password w = 77)

Skeptic: (x,y) = (100 , 29)

Round: 1
Prover: z = 9
Skeptic: b = 1
Prover: v = 69
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .5

Round: 2
Prover: z = 69
Skeptic: b = 1
Prover: v = 51
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .25

Round: 3
Prover: z = 89
Skeptic: b = 1
Prover: v = 41
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .125

Round: 4
Prover: z = 61
Skeptic: b = 0
Prover: u = 69
Skeptic: (u*u) MOD x = z: Ok.
Skeptic: Probability of lying = .0625

Round: 5
Prover: z = 89
Skeptic: b = 1
Prover: v = 59
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .03125

Round: 6
Prover: z = 49
Skeptic: b = 1
Prover: v = 61
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .015625

Round: 7
Prover: z = 69
Skeptic: b = 1
Prover: v = 49
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = .0078125

Round: 8
Prover: z = 89
Skeptic: b = 1
Prover: v = 9
Skeptic: (v*v) MOD x = (z*y) MOD x: Ok.
Skeptic: Probability of lying = 3.90625E-03

Round: 9
Prover: z = 21
Skeptic: b = 0
Prover: u = 11
Skeptic: (u*u) MOD x = z: Ok.
Skeptic: Probability of lying = 1.953125E-03

Round: 10
Prover: z = 49
Skeptic: b = 0
Prover: u = 93
Skeptic: (u*u) MOD x = z: Ok.
Skeptic: Probability of lying = 9.765625E-04
```

on human participation (such as the typing in of a password, or the response to a series of questions). However, in a world that is rapidly replacing paper with electronics, the zero-knowledge-proof method promises to be quite useful.

Banks, for instance, are heavily computerized businesses; increasingly, they rely on "smart cards" as a means of verifying customer identity. Under these circumstances, electronic eavesdropping can be as devastating to security and privacy as simply overhearing or glimpsing a password. The problem extends to communications between computers over the electronic networks that dominate the money markets; it is quite feasible for one computer to mimic another simply by "playing" the correct data stream. Zero-knowledge proofs may be able to help in these situations.

Zero-knowledge proofs will likely be a major factor in computer security systems of the future. ■

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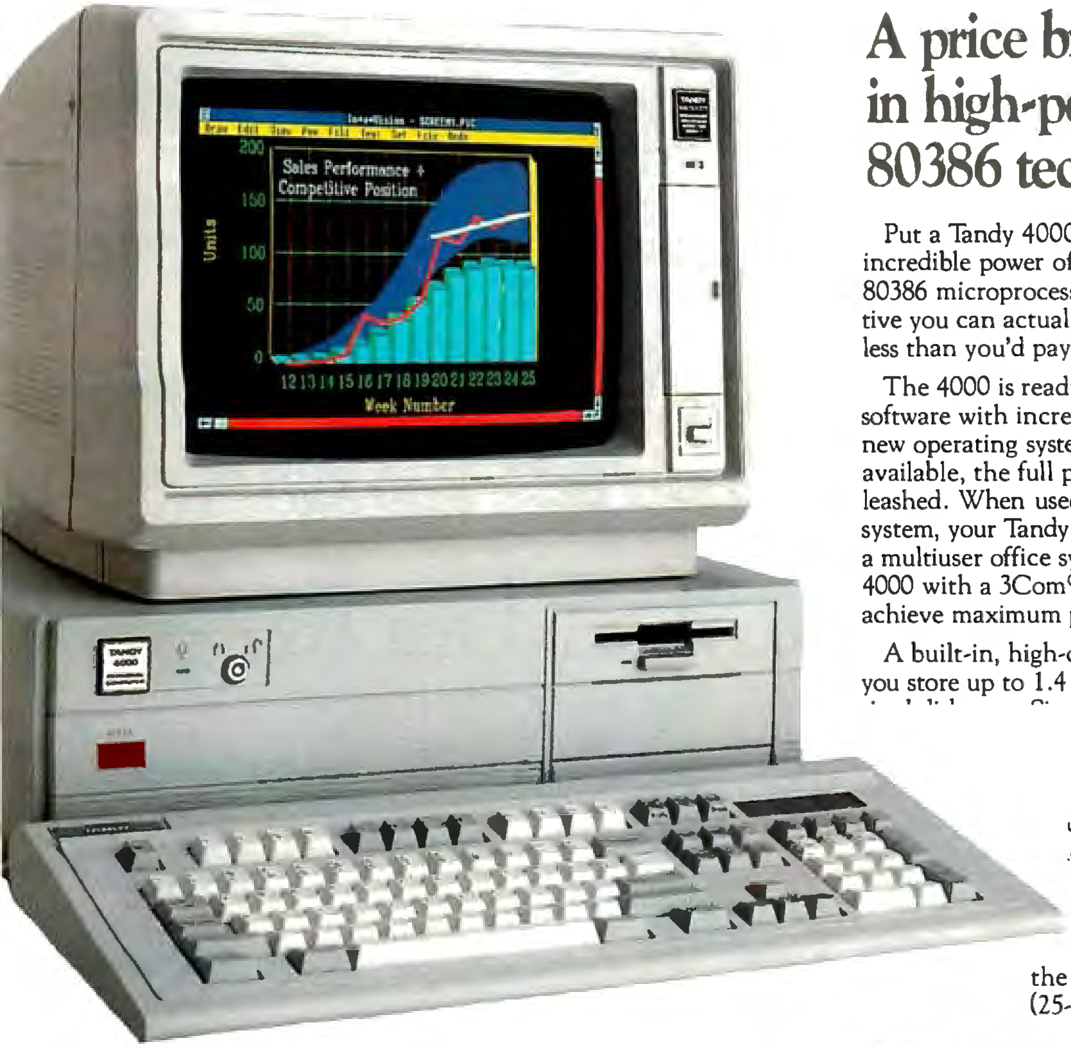

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Back-Propagation

A generalized delta learning rule

William P. Jones and Josiah Hoskins

A CHERISHED DREAM of the computer age is to build machines that can think as we do. How closely must the computer's internal representations and processes resemble those of a person for this to occur? The wisdom of the artificial intelligence community has long been that a close resemblance is neither necessary nor, given the architecture of a conventional computer, feasible. However, some recent impressive successes of the neural-network approach to the production of intelligent behavior have forced a reconsideration of this position. Computer-based neural networks, for example, have learned to speak (see reference 1), to induce kinship patterns (see references 2 and 3), to recognize handwritten characters (see reference 4), and even to play games (see reference 5). Do these proof-of-concept demonstrations presage a breakthrough in efforts to build intelligent machines?

Implementations of neural networks, it turns out, date back to the beginnings of the computer age (see reference 6), and it has long been known that some of the earlier, more basic networks are severely limited in the kinds of computations they can perform (see reference 7). What, then, is new in neural-network research that might justify the current wave of excitement? Some of the resurgence of interest is a consequence of recent hardware advances in the construction of massively parallel machines that may enable much faster simulations of a biological neural network. Other theoretical developments may dramatically increase the computational power of neural networks—even when these are realized in a conventional Von Neumann machine.

This article focuses on one such development by Rumelhart and colleagues (see reference 8) (with similar developments by Parker [see reference 9] and Le Cun [see reference 10]) known as the *back-propagation rule*. This is a powerful, general learning algorithm employing a gradient- or "steepest"-descent heuristic that enables a network to self-organize in ways that improve its performance over time. We will examine the back-propagation rule and demonstrate its learning capability with a simple neural-network simulation implemented in C. But first, we set the stage by discussing the neural-network approach and some of the events leading up to the development of the back-propagation rule.

The Neural-Network Approach

The neural-network approach, also referred to as *connectionism* or *parallel distributed processing*, adopts a "brain metaphor" of information processing. Intelligent behavior in a person seems to emerge from interactions involving huge numbers of neurons—each of which, compared to a computer, is quite limited in its processing capabilities (i.e., with regard to its speed, the information it acts upon, and the information it produces). Similarly, under a neural-network approach, information processing occurs through interactions involving large numbers of simulated neurons, such as the one depicted in figure 1. This simulated neuron, or unit, has four important components:

- *input connections* (synapses), through which the unit receives activation from other units.
- a *summation function* that combines the various input activations into a single activation.
- a *threshold function* that converts this summation of input activation into output activation (e.g., perhaps 0 output activation if the input activation falls below some threshold).
- *output connections* (axonal paths) by which a unit's output activation arrives as input activation at other units in the system.

An inter-unit connection in a computer-based neural network is typically assigned a numeric weight that modulates the activation passing through the connection. If the connection from unit A to unit B has a weight of w_{BA} for example, then the activation output of unit A might be multiplied by this value to determine the activation actually received by B. We can then represent the absence of a connection between A and B by simply assigning w_{BA} a value of 0. An inhibitory

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A neural network's input, output, and internal state can all be characterized by the patterns of node activations.

relation between A and B can be represented by giving w_{BA} a negative value.

It is instructive to draw two important contrasts between the neural-network approach and a more conventional *rule-based* approach found in AI expert-system work:

- The knowledge of a neural network lies in its inter-unit connections and their weights. In contrast, much of the knowledge of an expert system lies in its rules (i.e., its condition/action or if/then pairs).
- A neural network is driven by the activation that passes from units to other units. In contrast, an expert system is driven by symbols generated as a consequence of rule-firing.

Because only numerically valued activation passes from unit to unit in a neural network, neural networks are often said to involve a subsymbolic level of computation. A network's input, output, and internal state can all be characterized by patterns of activation across its nodes.

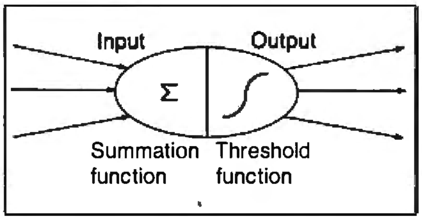

Figure 1: *A simulated neuron.*

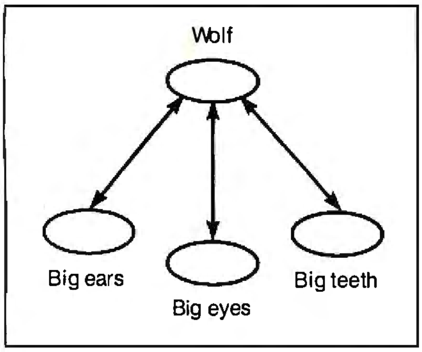

Figure 2: *A simple "wolf-detector" assemblage.*

How can intelligent behavior emerge from such very low level subsymbolic interactions among a network's units? It is sometimes helpful to view each unit as a classifier or a feature detector. Consider a simple example involving a tabula rasa Little Red Riding Hood who is sent to school to learn how to detect wolves in the forest. (Hopefully the school is not on the other side of the forest!) Little Red Riding Hood is shown a series of wolf pictures until she has internally formed the network depicted in figure 2. Input primitives in this example are the features of "big ears," "big eyes," and "big teeth." For each feature, there is a corresponding input unit with a rate of firing (i.e., an amount of output activation) that depends upon the extent to which this feature is detected in the outside world.

These input units, in turn, are connected to a unit corresponding to the "wolf" classifier unit. The actions of this unit's threshold function may cause it to behave like a Boolean AND so that it fires only when all three wolf features are observed. As the unit's threshold is lowered, it functions increasingly like a Boolean inclusive-OR, such that any combination of wolf-features is sufficient to trigger the wolf classification. It is through the combined effects of large numbers of such classifiers and input-unit feature detectors that intelligent behavior can emerge from a neural network.

The numerical base of the neural-network approach provides a ready means by which to represent continuous gradations in such things as the intensity of an input feature, the certainty of a classification, or the importance of a connection between two units. By contrast, such gradations are represented with great difficulty or not at all in most rule-based expert systems. Additional advantages of the neural-network approach may stem from properties of default assignment, content addressability, graceful degradation, and spontaneous generalization (see reference 11).

But how are the connections and connection weights of a network determined? As the size of a network increases, it is no longer feasible for the human designer to determine network connections by hand, nor is it feasible to engage the computer in a brute-force iterative search for the right connections. In a network with only a single layer of connections—those connecting input units to output units—there is a simple and elegant learning heuristic, the *delta rule*, that gives a network an ability to form and modify its own connections in ways that often rapidly approach a performance optimum. A brief discussion of the delta rule (sometimes called the Widrow/Hoff rule [see reference 12]) serves as an introduction to its recent successor, the more general and more powerful back-propagation rule.

The Basic Delta Rule

We describe the delta rule through the continuing education of our tabula rasa Little Red Riding Hood (LRRH). She will encounter three distinct beings in her world that we know as the wolf, the grandma, and the woodcutter. We limit LRRH to a single layer of connections between input nodes representing observable features and output nodes representing actions that LRRH can take. LRRH must learn to run away, scream, and look for the woodcutter when she detects a being with big ears, big eyes, and big teeth (the wolf). She must learn to approach, kiss on the cheek, and offer food to beings that are kindly, wrinkled, and that have big eyes (grandma). And she must learn to approach, offer food to, and flirt with beings that are handsome, kindly, and have big ears (the woodcutter).

Under these circumstances, the delta rule produced the network depicted in figure 3, with red lines corresponding to negatively weighted connections, and blue lines corresponding to positively weighted connections. Some features in the network have more diagnostic value than others (e.g., "big teeth" versus "big eyes"). However, LRRH need only correctly identify two features of a being in order to produce an appropriate set of actions using the network in figure 3.

The training procedure used in conjunction with the delta rule to produce the network in figure 3 is straightforward. There are three I/O training pairs, one each for the wolf, grandma, and the woodcutter. An input pattern I is represented by a vector of 0s and 1s that follow the ordering of input nodes in figure 3. Thus, the input pattern for the wolf is [1 1 1 0 0 0]. The target output pattern T that we want LRRH to produce in response to an input pattern can be similarly represented. Thus, the target output pattern for the wolf is [1 1 1 0 0 0 0]. Before training begins, connections between all input nodes and all output nodes are formed, and each connection is randomly given a small, initializing weight.

Training using the delta rule then proceeds by cycling through the training pairs until a satisfactory level of performance is reached. On a given trial, the network first generates an output pattern O_p in response to the input pattern I_p of a training pair. The discrepancy, or delta, between the actual and the desired behav-

continued

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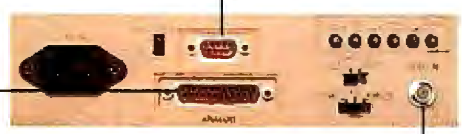

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ior of the network is then determined by subtracting vector O_p from the target output pattern T_p of the training pattern. Under the delta rule, the post-trial change in the weight w_{ji} of a connection between input unit U_i and output unit O_j is a function of the activation I_{pi} of the input unit and the delta $(T_{pj} - O_{pj})$ associated with the output unit. Specifically,

$$\Delta w_{ji} = n(T_{pj} - O_{pj})I_{pi} \qquad (1)$$

where n represents a trial-independent learning rate. (As the learning rate increases, so too does the risk of oscillatory behavior.)

The delta rule essentially assigns credit (or blame) to the input units according to their activation levels; the more active an input unit, the more responsible it is (or should be) for the current distribution of activation among output units. The effect, then, is that connections pointing from the more active input units of a trial will undergo the largest modification in their weights. At the same time, among connections pointing from a given input unit, the larger modifications will involve those connections that point to output units with larger associated deltas (i.e., discrepancies between actual and target activation levels).

It can be shown that the delta rule belongs to a class of gradient- or steepest-descent heuristics. This means that the delta rule will cause a network of connections to change in directions that maximize the change in an error term that sums the squares of output deltas. One way to view this feature is to see the delta rule as a skier who always moves with the fall-line in a breakneck journey back to the clubhouse.

Limitations of the Basic Delta Rule

The basic delta rule works quite well at assigning connections and connection weights in single-layered systems (involving only input units and output units), but it is unable to determine connection weights in a multilayered system involving *hidden units* (units that have no direct contacts with the outside world). In a careful analysis done nearly 20 years ago, Minsky and Papert (see reference 7) delineated a number of interesting computations that single-layered systems cannot perform. For example, they cannot compute the exclusive-OR. To take a concrete situation, a single-layer system cannot learn a preference for classes meeting on Monday or Wednesday evenings but not (e.g., because of time constraints) meeting both evenings. Table 1 illustrates the problem. There is simply no linear combination of variables M and W (for Monday and Wednesday classes, respectively) that will generate the desired values of the exclusive-OR.

In a sense, single-layered networks are limited to computations that map similar-looking input patterns into similar-looking output patterns. In many computations such as the exclusive-OR relation or the more general parity computation, a small change in the input pattern may necessitate a drastic change in the desired output pattern. In these instances, we need multiple-layered networks with hidden units. Through hidden units, the system can represent abstractions that it cannot directly encode from the environment via input nodes.

Figure 4 illustrates that a simple two-level network with only one hidden unit can compute the exclusive-OR. In this case, the hidden unit represents the abstraction "Monday and Wednesday." With the right set of connections to and from a large enough set of hidden units, a network can perform any desired mapping between input and output. (It is often the case that hidden units will also reduce the number of connections needed to perform a particular computation—a point we return to in the example of the next section.) Much of the current resurgence of interest in neural networks can be traced to the development of a powerful generalization of the delta rule that can arrive at such a set of connections in a multilayered system. This back-propagation rule (see reference 8) is described in the next section.

Back-Propagation

The equation that determines weight changes under the back-propagation rule is similar in form to that of equation 1. However, the back-propagation rule provides a more general means of computing the delta of a unit. On a given trial, the delta of an output unit is computed in

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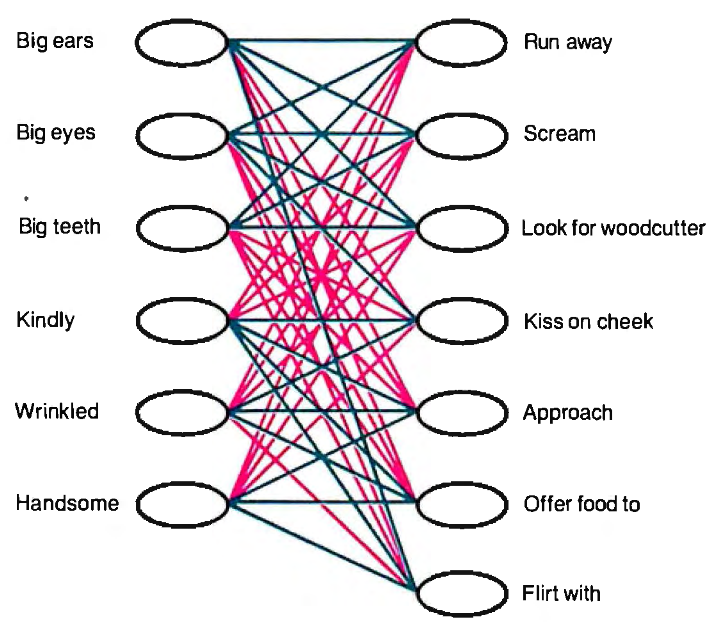

Figure 3: *A network produced by the basic delta learning rule.*

Table 1: *The exclusive-OR problem.*

Monday	Wednesday	XOR (M,W)
0	0	0
1	0	1
0	1	1
1	1	0

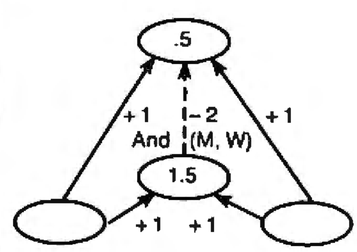

Figure 4: *A network solution to the exclusive-OR problem.*

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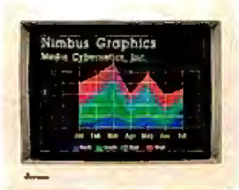

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much the same way as it is computed in the basic delta rule. Specifically,

$$\delta_{pj} = (T_{pj} - O_{pj}))f'_j(net_{pj}) \quad (2)$$

where $f'_j(net_{pj})$ is the derivative of a "squashing" function that operates on the sum of the inputs to a unit in order to determine the unit's output. A squashing function is a special kind of threshold function that is differentiable and nondecreasing. Such a function can be found in the listing of our C language implementation of the back-propagation rule. [Editor's note: *The source code for bpsim.c is available on disk, in print, and on BIX. See the insert card following page 304 for details. The listing is also available on BYTEnet. See page 4. Bpsim.c, which must be compiled and run on Unix systems, illustrates the Little Red Riding Hood example in this article.*] In a linear system with no squashing function, the output of a unit equals its input. In this special circumstance, the delta produced by the back-propagation rule is identical to that produced by the basic delta rule.

The real power of the back-propagation rule comes from its assignment of deltas to hidden units that receive no direct feedback from training patterns in the outside world. These deltas, in turn, influence the modification of weights to connections leading into the hidden units. The delta for a hidden unit is computed as follows:

$$\delta_{pj} = f'_j(net_{pj})\Sigma_k \delta_{pk} w_{kj} \quad (3)$$

This is a recursive definition in which the unit's delta is determined by the derivative of its squashing function multiplied by the weighted sum of the deltas to which the unit sends activation via outgoing connections. A given delta term δ_{pk} in the summation is, in fact, weighted by the strength of the connection pointing from the hidden unit U_j to the unit U_k that is the source of the delta.

As the back-propagation rule's name suggests, the basic idea behind this computation of deltas for internal units is to propagate back through the system errors that are based on observed discrepancies between the values of output units and a training pattern. The deltas are first computed for the output units, and these are then propagated backward to all units pointing to the output units in the layer below. These units, in turn, propagate their received deltas backward to units that point to them, and so on, until the input level is reached. These deltas then drive the network's weight changes in much the same way as with the basic delta rule; the back-propagation rule, like its basic delta rule predecessor, is a gradient-descent heuristic.

We return to the tutoring of Little Red Riding Hood to illustrate the effects of the back-propagation rule with a more concrete example. Suppose we were to follow the same training procedure used to generate the network in figure 3, but now we introduce three hidden units. Initially, each input unit is connected (with some low, randomly determined weight) to all three hidden units; similarly, each hidden unit is connected to all output units. No connections are permitted that directly connect input to output units. We now have two layers of connections, necessitating the use of the back-propagation learning rule.

Figure 5 shows the results of this experiment. Interestingly, the hidden units have come to represent internally the concepts for wolves, grandmas, and woodcutters. It is often the case that hidden units, through the actions of back-propagation, will come to represent useful abstractions of the outside world. Note that the I/O mapping in this example does not require the use of hidden units. As figure 3 indicates, this mapping can be accomplished without hidden units using the basic delta rule. It is, nevertheless, interesting to note that the introduction of hidden units in figure 5 reduces the number of connections needed to represent the mapping.

Applications and Future Directions

In principle, the use of the back-propagation algorithm would seem to give a system the ability to induce an I/O mapping of arbitrary complexity—providing that the system has enough units and connections at its disposal. As such, the back-propagation algorithm and related work may profoundly alter our use of computers. Much of the current applied work on neural networks is focused on the construction of pattern-recognition systems (i.e., systems that can recognize handwriting, gestures, images, and so on). But the range of potential applications is clearly much broader.

Consider the economic value of a system that observes and eventually mimics the behavior of a domain expert. Currently, the construction of expert systems often requires an enormous amount of effort. Rules must be laboriously abstracted, entered, and checked for poten-

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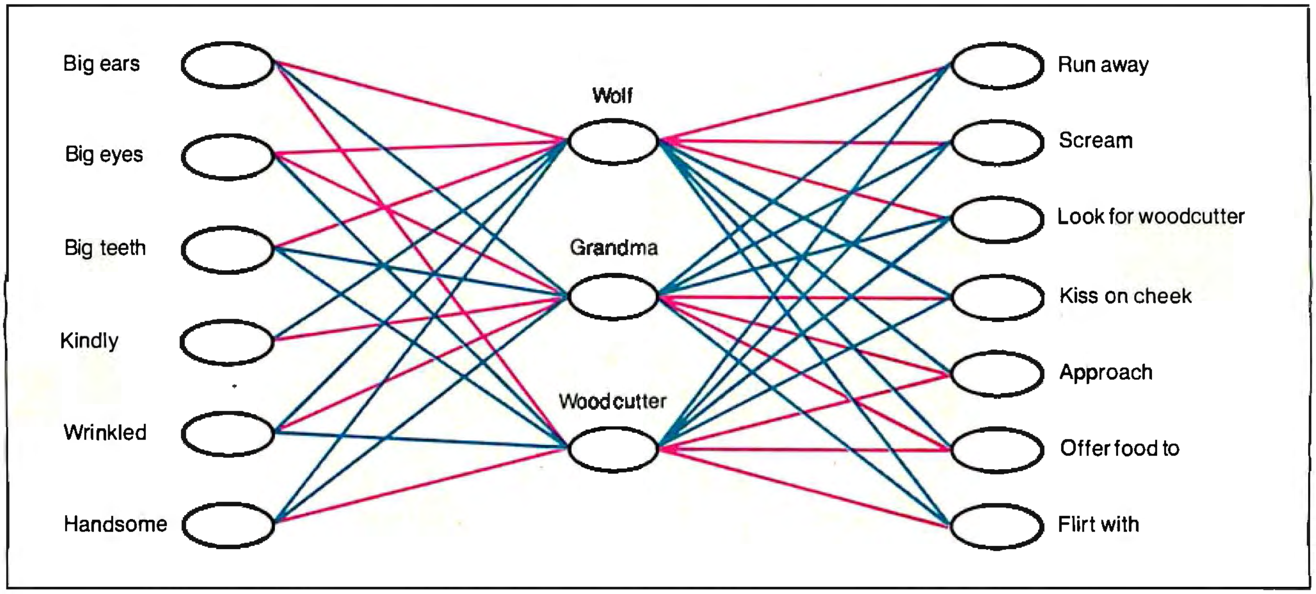

Figure 5: *A network produced by the back-propagation learning rule.*

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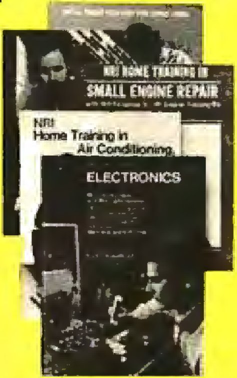

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tial incompatibilities with the existing rule base. Moreover, as the saying goes, "rules are made to be broken." All too often, expert systems are brittle, so that their performance precipitously degrades in situations not anticipated by their human designers. As an alternative, a neural-network approach using back-propagation may give us a system that essentially builds its own rule base with a minimum of outside intervention, so that over time it gradually takes over the tasks of the human expert. In this direction, work is currently under way to build an adaptive neural-network system to aid in fault detection and diagnosis in a chemical-engineering plant (see reference 13).

On the downside, neural-network implementations involving the back-propagation rule can be demanding of computational resources (see reference 14). As we noted, one general approach to this problem is to completely redo machine architecture in ways that support massively parallel computation. It may also turn out that many important applications permit limited implementations of the back-propagation rule that are extremely fast even on today's smaller computers.

Will the neural-network approach, in conjunction with techniques such as the back-propagation rule, usher in a new age of computing? Or will it, like so many developments in the AI field, prove to have a grasp that falls far short of its reach? Only time will tell. ■

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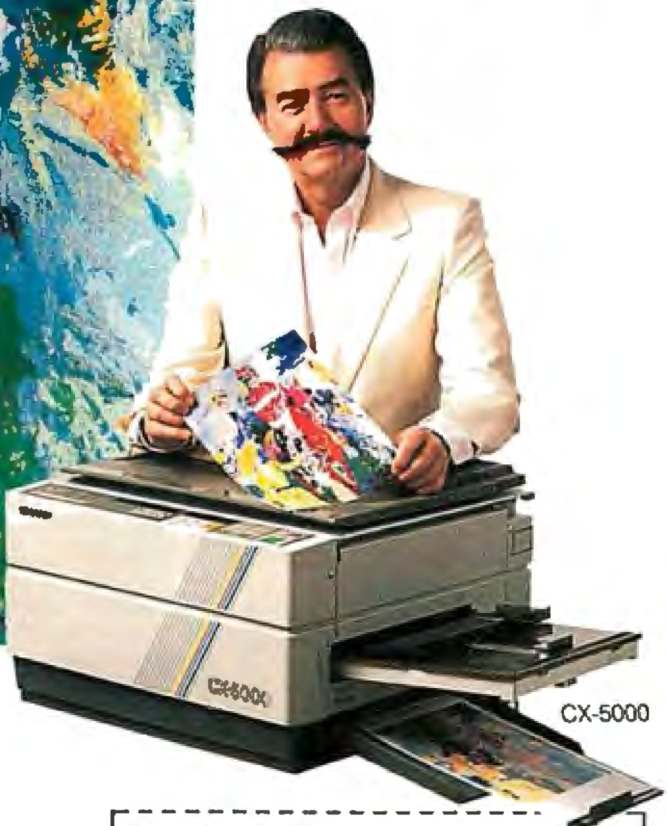

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Optimizing Compilers

How compilers produce fast code, and how they could be improved

Mark Roberts

AN OPTIMIZING COMPILER'S purpose in life is not a simple one: It must attempt, by making the resulting machine code either smaller or faster, to improve a program's performance without changing the program's intent. Since small portions of a program account for most of the run time, streamlining the heavily used portions can result in a dramatic increase in performance. A good programmer, drawing on years of experience and expertise with the system hardware, can write efficient code for those critical routines that require fine-tuning. Compilers generate machine code without the benefit of representative input data or experience, so identifying and eliminating these performance bottlenecks turns into an automated guessing game.

A compiler using heuristic algorithms would eliminate the guesswork by using data gathered from the analysis of the program to generate the best code for a particular sequence of program instructions. I'll present some examples of C language code and the optimizations (or program transformations) that can be achieved by a compiler, briefly noting where heuristic capabilities could result in the generation of better code.

The Scope of Compilers

Optimizing compilers can be characterized by the *scope* of their optimizations; that is, how much of the user's program they will consider at one time while searching for and performing transformations. As you would expect, the complexity of a compiler increases dramatically as its scope expands.

The scope of program transformations can be broken down into five basic levels:

1. Statement: A single line of the program.
2. Basic block: A sequence of statements with only one entrance and one exit.
3. Loop: A sequence of statements executed repetitively.
4. Procedure (or Intraprocedural): An entire procedure (or subroutine or function). Although procedure-level optimization is often referred to as "global," this term is somewhat misleading, since a procedure is clearly not the most global view of a user's program. Since the bulk of literature uses the term *global* in this manner, I'll do the same for the sake of consistency.
5. Program (or Interprocedural): The entire program, not including assembly language and standard library routines.

Most compilers perform at least some optimizations at the block, or local, level (level 2). Since the data-dependence relationships within a basic block can be found by relatively simple analysis techniques, the optimizations performed on basic blocks can usually be more elaborate than those performed on the program as a whole. Many mainframe compilers optimize at the procedure, or global, level (level 4). Alternate methods of optimizations are also possible. For example, certain microcomputer compilers adopt optimization strategies similar to those of mainframe compilers, but, instead of operating on procedures, these compilers limit their global optimizations to loops. A compiler using interprocedural optimizations and heuristic techniques could perform optimizations using data gathered from the analysis of most of or all the procedures in a program.

Optimization Techniques

Optimization techniques fall into two basic classes: *machine-independent* and *machine-dependent*. This article focuses on a number of machine-independent optimizations, but I'll also cover some machine-dependent techniques as well.

Machine-independent techniques focus on an intermediate representation of a program—the program's logic—that is independent of the target machine. Machine-independent optimizations preserve the semantic correctness of the program but reduce its running time, memory requirements, or both. This is not to say that these techniques are totally divorced from the architecture of the processor involved: Not all machine-independent program transformations will run with equal facility on certain machine architectures.

Machine-dependent optimizations must also preserve semantic correctness but focus on using the strengths and weaknesses of a particular machine architecture.

Both techniques reorganize the structure and elements of a programmer's code

continued

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The trade-off is more activity and slower speeds at compile time for faster programs at execution time.

when it is compiled. These manipulations basically reduce the amount of code the computer must handle at execution time, so the program runs with increased efficiency. The trade-off is increased activity and slower speeds at compilation time in exchange for faster programs at execution time. It's important to note that while these optimizations by no means guarantee the best possible code, the results should at least mean a reduction in code size or an increase in speed. Moreover, an optimizing compiler obtains results far quicker than a programmer.

Some Machine-Independent Techniques

As stated earlier, certain optimizations can be performed by analyzing the program's logic. These logic optimizations are independent of the machine type and are usually independent of the programming language being used. Let's look at several things that can be done to reduce code in a program.

Constant arithmetic: Also known as constant folding, this technique evaluates constant expressions at compile time and replaces them with the computed result. Arithmetic expressions should be evaluated the same way at compile time as they are at run time, since many constant expressions arise through the use of symbolic constants in these expressions. Constant terms in array subscript expressions can be integrated with the array address at compilation time. Unnecessary arithmetic, such as `m * 1` or `b - 0`, and unnecessary logical operations are eliminated. Conversion of a constant from one type to another is performed.

As a simple example of constant folding, the statement `flt = 1.5 + 3.2;` is compiled as `flt = 4.7;`.

Constant propagation: This replaces the use of variables assigned a constant by the constant itself. This in turn can create more opportunities for constant folding. For example, `j = 2; k = j + 5;` are compiled as `j = 2; k = 7;`.

Common subexpression elimination: This technique involves finding and eliminating those computations that calculate values already available. An occurrence of an expression E is called a *common subexpression* if E was previously computed and the values of the variables in E have not changed since the previous computation.

Common subexpressions can be saved in registers or memory and accessed there instead of being recalculated at each use. With the use of this technique, expressions such as

```
a = b + c * d; ... x = c * d/y;
```

are compiled as

```
t = c * d; a = b + t; ... x = t/y;,
```

where `t` is a compiler-generated temporary variable that will be assigned to a register where possible.

Dead store elimination: A variable is "live" at a point in a program if its value is subsequently used; otherwise, it is "dead" and can be eliminated. A related idea is dead or useless code—code that computes a value that is never used. While a programmer is unlikely to intentionally introduce dead code, it can appear as the result of previous transformations, such as constant folding or copy propagation.

Copy propagation: References to a variable can be replaced by the expression previously assigned to that variable. For example, consider the statements

```
x = a + b;      c = a;      y = c + b;.
```

Copy propagation would determine that the variable `c` can be discarded and replaced with `a`, so that `y = c + b` becomes `y = a + b`. Copy propagation alone is not an optimization, but combined with common subexpression elimination, dead store elimination, and the appropriate register allocation (which I'll discuss in more detail later), the program may be improved. Continuing with our example, the statements ultimately compile as

```
t = a + b;      x = t;      y = t;,
```

where `t`, as before, is a temporary variable.

Two recent types of machine-independent optimizations are *interprocedural constant propagation* and *procedure embedding*. Interprocedural constant propagation would analyze all procedures in a program (level 5) rather than from within a procedure (level 4) to perform optimization by constant propagation. In procedure embedding, a procedure call is treated as a macro expansion; that is, the text of the procedure is expanded in-line and optimized together with the calling routine. The optimizer could then fold constant arguments into the code or move invariant instructions into less frequently executed regions of the calling routine. In both cases, heuristic analysis could provide the capabilities of selecting the optimizations across procedures that would generate smaller and faster code. Since each program is unique, heuristics would provide the flexibility to handle special or unusual cases when the rules presented here break down.

Loop Optimizations

An important place for other machine-independent optimizations is loops (level 3), especially inner loops, where programs tend to spend the bulk of their time. We can improve program execution time by decreasing the number of instructions in an inner loop, even if that increases the amount of code outside the loop. Three techniques are important for loop optimization: invariant code motion, strength reduction, and induction-variable elimination.

Invariant code motion: The intent of code motion is to move instructions from frequently executed areas of the program to less frequently executed areas. An expression can be moved out of a loop if the value it produces is not changed by this move and if it computes the same value for every iteration of the loop. For example, the statement

```
for (i = 0; i < 10; i++)
   array[i] = x + y;
```

would be compiled as

```
t = x + y;
 for (i = 0; i < 10; i++)
   array[i] = t;.
```

Since relative execution frequencies of various areas of a program are not always readily apparent, moving code may not always improve the results.

Strength reduction: This optimization replaces certain computations that use recursively defined variables with recursively defined computations that use less computationally expensive machine operations. By way of example, the statement

```
for (i = 0; i < 10; i++)
   array[i] = i * 4;
```

would be compiled as

```
t = 0;
for (i = 0; i < 10; i++)
   {
   array[i] = t;
   t += 4;
   }.
```

continued

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The advantage here is that a particular computation (the multiply statement) is replaced by a faster one (the addition with sum statement).

A more important example of strength reduction would be optimizing the use of the array[i] term. The address calculation probably involves a multiply by 2 or 4. Hence, the code produced by an optimizing compiler for this example would resemble typical C language array referencing with pointers:

```
t = 0;
p = &array;
for (i = 0; i < 10; i++)
   {
   *(p++) = t;
   t += 4;
   }.
```

Notice that i is no longer used in the loop at all. This leads us to our next subject.

Induction-variable elimination: In the context of this article, an induction variable is a variable whose value is modified by a fixed amount each time the loop is executed. When there are two or more induction variables in a loop, it may be possible to eliminate all but one.

After performing the strength-reduction optimization and introducing new recursively defined variables, frequently the only use for the original recursively defined variable is for the loop-control test. This test can often be replaced by a test on one of the introduced variables, thereby making the instructions associated with initializing and incrementing the program variable no longer necessary. Our example now becomes

```
p = &array;
for (t = 0; t < 40; t += 4)
   *(p++) = t;,
```

where the induction variable i has been replaced by the variable t.

Loop unrolling: A loop can be unrolled completely so that the successive computations implied by the loop appear sequentially, or it can be partially unrolled, as in the following example. The original loop code looks like this:

```
for (i = 0; i < 100; i++)
   a[i] = a[i] + b[i];.
```

When the loop is unrolled by 2, the code becomes

```
for (i = 0; i < 100; i += 2)
   {
   a[i] = a[i] + b[i];
   a[i+1] = a[i+1] + b[i+1];
   }.
```

Loop unrolling has two major advantages. First, the number of increments and tests for loop control is cut in half in this example. Second, more instructions are exposed for parallel execution. Nests of loops can also be unrolled. A loop with variable control parameters, such as for (i = j; i < k; i += 1), can be unrolled, but it requires extra code to test for end conditions.

The major disadvantage of loop unrolling is that it improves performance at the cost of additional instructions. For this reason, the criteria for unrolling loops should include the size of the loop and the relative frequency of executing the loop. Other factors include the severity of the object space constraints and the form of the loop itself. In these situations, an experienced programmer can decide whether to unroll a loop. Heuristic analysis of these criteria in a compiler could allow sensible code-generation of program loops, and in a fraction of the time.

Loop jamming: In this transformation (also called loop fusion), two loops are put together and expressed by one loop. This reduces loop overhead and code space while exposing more instructions for parallel execution and local optimization. Since there are no disadvantages to making this transformation, it should be used wherever possible.

The cases that can be transformed are relatively simple or fairly elaborate. The simplest case involves two loops that together satisfy several criteria. First, if one loop is executed, then so is the other one; that is, the two loops should have the same execution conditions. Second, the computations in one loop do not depend on computations in the other. This criterion can easily be relaxed in particular situations. Last, the loops are executed the same number of times. By generating code for the end conditions, this criterion can be relaxed as well.

Here's an example of a simple case. The code for the two loops is

```
for (i = 0; i < 100; i++)
   a[i] = 0;
for (i = 0; i < 100; i++)
   b[i] = x[i] + y;,
```

which becomes

```
for (i = 0; i < 100; i++)
   {
   a[i] = 0;
   b[i] = x[i] + y;
   }.
```

The need for this transformation may arise when compiling languages that have array or vector operations. If statements involving these operations are translated to the more basic element-by-element operations, fusible loops and nests of loops may appear frequently in the code.

Machine-Dependent Techniques

Rather than manipulating a programmer's code, machine-dependent techniques involve determining the fastest way to perform a specific operation, given the architecture of a processor. The intent of machine-dependent optimizations is, figuratively, to squeeze the processor for every possible degree of speed by using all its features to optimum advantage. I'll look briefly at register allocation, operand permutation, instruction scheduling, and peephole optimization.

Register allocation: One key to designing an optimizing compiler is to make efficient use of the target machine's registers. It takes a comparatively long period of time for the processor to retrieve data from memory, as opposed to retrieving it from registers. Therefore, the goal is to maintain "register residency" for values used most often in a user's program.

Allocating registers is possibly the most difficult optimization to perform. Several issues can be isolated in the use of this optimization technique. The first issue is whether register allocation can be separated from register assignment. Allocation involves determining how many program values should be held in registers. Assignment involves determining which actual hardware registers will be used for each allocated register. One problem associated with register assignment is boundary matching: An entity used in two or more program blocks that are executed sequentially should be assigned to the same register, if possible.

The second issue is load-store motion. Load-store motion moves the LOAD and STORE instructions out of loops to retain intermediate results in registers and to avoid unnecessary storage references. However, other instructions can also be moved to obtain a better allocation.

The last issue is using local or global allocation and assignment of registers. The allocation of code within a basic block (local) may use simpler techniques than allocation across basic-block boundaries (global), since the latter must consider control flow. An optimizing allocation normally consists of both local and global allocation.

Operand permutation: By changing the order of evaluation of expressions, the number of registers needed to do a calculation can be reduced. For example, since results require fewer registers than computations, you might always generate the operation that needs the most registers first. Once the complex operation is per-

continued

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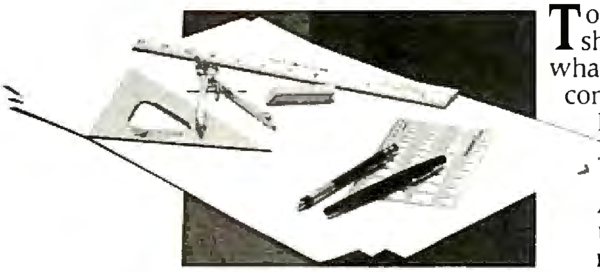

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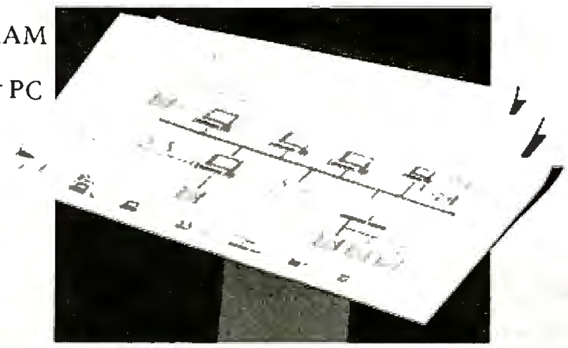

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formed, you have registers free that can store the results of the operation for further optimizations.

Instruction scheduling: In this optimization, sequences of instructions are ordered to minimize the execution time of the sequence. This optimization is of particular importance when the target processor has a pipelined instruction fetch. For example, instruction scheduling is important on many reduced instruction set computers (RISCs) that always prefetch and execute the instruction following a branch instruction, regardless of whether the branch is taken. Rather than simply place a NOP after the branch, an optimizing compiler can often reorder the instruction sequence to place a useful operation there.

Peephole optimization: The final code from a compiler can often be improved simply by a local scan of the sequence of instructions. A window of 5 to 10 instructions can be examined for possible transformations. When certain combinations of instructions are detected, they can be replaced by a smaller and/or faster set of instructions that accomplish the same function.

In addition to the machine-dependent optimizations just presented, most processor/operating-system combinations have a "standard" calling sequence used to invoke most external procedures. An interprocedural optimizer, coupled with heuristic analysis of the code, could modify this protocol on a procedure-by-procedure basis. For example, a function `random()` that has only a single floating-point argument could be compiled to always get its argument in a specific floating-point machine register. This might save both a PUSH and a POP via the normal argument stack.

A Look into the Future of Compilers

Compiler research is being conducted in a wide variety of areas today. A cursory look at recent computing literature will attest to this. Two interesting directions that relate directly to the topics covered in this article are interprocedural optimization and vectorization/parallelization. Richardson and Ganapathi have produced a good bibliography covering interprocedural optimizing, and Padua and Wolfe present a survey of vectorization in the December 1986 *CACM*.

I've mentioned instances in this article where interprocedural optimizations could assist in the generation of better code. Another possibility would be optimizations based on execution profile data maintained by the development environment—the heuristic analysis I've mentioned. One example would be a technique that biases the code generated for if statements so that the most frequently occurring case is the fall-through path. This can improve execution performance on machines like the Intel 80386 by keeping the instruction prefetch queue full.

Vectorizing compilers have been around since the late 1970s, but until recently, only a few programmers with access to a Cray or Cyber supercomputer have used one. But as the cost of high-performance computers continues to fall, we will see more and more medium-priced vector machines, as well as "supercomputers" based on networks of so-called general-purpose microprocessors. Compilers that can discover and exploit the parallelism inherent in many programs will be needed to take full advantage of these machines.

Owning today's microcomputers is comparable to having a 1960s mainframe on your desk. As these machines become more powerful, users expect more from a compiler to help them take advantage of this power. User demand, together with the machine's advancing capabilities, is leading us toward better and more powerful compilers. Within as little as a year or two, we will probably see truly state-of-the-art optimizing compilers for the microcomputers now on our desks. ■

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A Search Strategy for Commonsense Logic Programming

A heuristic algorithm for searching

Paul V. Haley

PROLOG, THE DE FACTO logic programming language, is widely assumed to be a problem solver that reasons logically. However, its fixed search strategy often causes its reasoning to violate our notions of common sense.

Just as human beings use common sense to cope with the real world, real-world computer programs need to be able to pursue appropriate goals. I'll discuss some architectural characteristics that would enable a truly logical programming language to implement common sense using heuristics. Incorporation of heuristics in modern programming languages could give us the ability to write "smart" programs. Smart programs should be more efficient than programs that use brute-force algorithms.

Unfortunately, an actual solution to the problems associated with certain kinds of inefficient programs does not yet exist. My goal here is to stimulate thought about logical reasoning using searches, and how such searches might be made to more closely resemble human approaches to problem solving. Unfortunately, even though I outline the scheme for a solution to the problems associated with "dumb" programs, an actual solution does not yet exist.

Initial States

Any problem solver starts in an initial state and determines a sequence in which to apply appropriate operators in order to transform the initial state into a goal state. Prolog's states are the goals on its stack and the contents of its propositional database (predicates and facts). Prolog's operators are its rules of logical implication. These rules generate goals and deduce new facts that change Prolog's problem-solving state.

Conventional programming languages provide a rich vocabulary of control constructs that, when used properly, can lead a program directly to a solution. Searching is performed at the option of a programmer and is expressed using these unambiguous control constructs. Prolog, on the other hand, provides very little in the way of direct control. Prolog's rules of logical implication are best viewed as statements of truth, with the language itself deciding when to apply a rule.

Prolog determines whether something is true by first looking for an explicit proposition in its database. It then tries to derive this proposition by checking whether it is implied by other contents of the database. To determine whether something is implied, given these contents, Prolog must search for an applicable rule. Since more than one rule might be capable of determining whether something is true, Prolog must choose a rule to investigate first.

All Prolog implementations check rules in the order in which they occur; this is referred to as *depth-first* search. Since, in checking a rule, Prolog might need to find out if some other thing is true, it also supports recursion by using a stack. When going back up the stack from a failure to determine something to be true, Prolog is said to *backtrack*. Thus, Prolog's control algorithm is depth-first searching with backtracking.

In general, the search strategy used by an inference engine has a direct impact on the efficiency and the intuitive plausibility of the resulting logical reasoning. The search strategies used manifest themselves in reasoning behaviors that can have varying degrees of efficiency and that vary in their plausibility as cognitive models of how people reason. As always, efficiency is important in computer programs. However, for programs attempting to emulate human problem-solving capabilities, the plausibility of the reasoning employed takes on critical significance. Programs that behave mechanically until they stumble across a solution to a problem are clearly less intelligent than programs that proceed directly toward a solution without wasting time pursuing fruitless directions.

The Problem

For example, to get from point A to point B, you might be able to walk, ride, or fly. You might walk to your car, ride to the airport, and fly to your destination. If no direct flight was available, you might travel to an intermediate destination and travel on from there. The following Prolog pseudocode encodes some of this knowledge.

```
Travel(A,B) :=Walk(A,B);
             Ride(A,B);
             Fly(A,B).
```

continued

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In Prolog, there can never be a goal more relevant than the one most recently generated.

```
Ride(A,B) := Drive(A,B);
             Bike(A,B);
             Taxi(A,B);
             Train(A,B);
             Bus(A,B).
```

Few people trying to get from New York to London would seriously consider walking or taking a bus or taxi. Common sense would dictate that you needed to fly. Once you knew how to take care of the unfamiliar parts of the trip, you would think for a moment to ensure that you could get a ride to the airport. You would probably never think of walking at all. However, consider the behavior of the Prolog program below. Without going into great detail, the program would pursue, fail to achieve, and finally achieve goals something like this (< = denotes a failure to achieve, and = > indicates achievement of a goal):

```
=> Goal(Travel(New York,London))
   => Goal(Walk(New York,London))
   <= Goal(Walk(New York,London))
   => Goal(Ride(New York,London))
   => Goal(Drive(New York,London))
   <= Goal(Drive(New York,London))
   => Goal(Bike(New York,London))
   <= Goal(Bike(New York,London))
   => Goal(Taxi(New York,London))
   <= Goal(Taxi(New York,London))
   => Goal(Train(New York,London))
   <= Goal(Train(New York,London))
   => Goal(Bus(New York,London))
   <= Goal(Bus(New York,London))
   <= Goal(Ride(New York,London))
   => Goal(Fly(New York,London))
   => Fly(New York,London)
=>Travel(New York,London)
```

This Prolog program does not display common sense. Because it pursues a goal by checking the next rule that might achieve that goal, Prolog is prone to a fatal catch-22: It can't pursue the most relevant goal if that goal hasn't already been generated. However, Prolog generates goals only by checking the next rule that could derive the most recent goal. That is, Prolog never generates an alternative goal. Thus, there can never be a goal that is more relevant than the one most recently generated. This is not very satisfying.

It is difficult to write a Prolog program that will display common sense in a variety of situations. For instance, in our travel example, many considerations must be weighed to qualify the feasibility of driving as an appropriate mode of transportation: There has to be a road to drive on; the road has to be passable; there must be a car; it must start; it must have enough gas to travel at least as far as the next gas station; the next gas station has to be open; if the car has a diesel engine, the gas station has to sell diesel fuel; there must be sufficient money to pay for the fuel required; and so on. All these conditions would have to be explicitly stipulated and satisfied.

People don't consider every possible detail in this way. They solve such trivial problems without effort; it's simply "common sense." They think about roads only if they know they will be driving; they don't worry about gas stations unless there is a compelling reason, such as crossing an uninhabited desert.

Common sense seems to involve choosing what to consider and what to ignore. Unfortunately, deciding to ignore certain details can result in unsound or incomplete "logical" formulations. For example, by not considering whether there is a road to the top of Mount Everest, a program might reach the unsound conclusion that one could drive there. Fortunately, deciding the order in which to consider things will never, in itself, lead to an erroneous conclusion. If the first goal considered is unfruitful, the correct alternative is not abandoned—it is only delayed. To the extent that a program orders alternatives intelligently, it will pursue fewer fruitless goals and therefore be more efficient.

Consider again our travel rule:

```
Travel(A,B) := Walk(A,B);
               Ride(A,B);
               Fly(A,B).
```

In response to a goal to get from A to B, Prolog will always "think about" walking before flying. There is nothing we can do about this algorithmically correct, but maddeningly counter-intuitive, behavior. One method to provide this system with some common sense is to use heuristics.

A Heuristic Search Solution

In an architecture supporting heuristics, the travel rule could simultaneously generate the following goals:

```
Goal(Walk(New York,London))
Goal(Ride(New York,London))
Goal(Fly(New York,London))
```

For these goals to exist simultaneously, they would have to be represented as data in the propositional database rather than being procedure calls that exist transiently on the stack, as in Prolog. We could then reason about these goals just as flexibly as if they were facts in Prolog's database. Using this approach, rules can be checked in response to new goal data, rather than in response to recursive procedure calls, as in Prolog.

The travel rule takes on a new look from this perspective. It is equivalent to these three rules:

```
Goal(Travel(A,B)),Walk(A,B) ->
     Travel(A,B)
Goal(Travel(A,B)),Ride(A,B) ->
     Travel(A,B)
Goal(Travel(A,B)),Fly(A,B) ->
     Travel(A,B)
```

When the goal to travel from New York to London is pursued, each of these rules responds in parallel, generating the following goals:

```
Goal(Walk(New York,London))
Goal(Ride(New York,London))
Goal(Fly(New York,London))
```

All three of these, in addition to the original goal, are represented as data in the propositional database. Given the possible methods of travel from New York to London, each represented as one of the above subgoals, how does the program determine what goal to consider first? Each time a goal is generated, the program can evaluate it according to its set of heuristics. Each heuristic can cast a vote in favor of pursuing a specific goal. The goal with the most votes is deemed the best. The inference engine then checks all rules that might achieve this goal, or any subgoal, and executes any applicable rules until none remain. By always pursuing the best goal, this inference engine performs a "best-first" search. We might use heuristics of the form

```
Heuristic1:
  Goal(Fly(A,B)),
  Distance_between(A,B,Distance),
  Distance > fly_threshold
  ->
  VoteFor(Goal(Fly(A,B))).

Heuristic2:
  Goal(Walk(A,B)),
  Distance_between(A,B,Distance),
  Distance < walk_threshold
  ->
  VoteFor(Goal(Walk(A,B))).
```

These are domain-specific heuristics that cause the program to first consider flying for long trips and walking for short trips.

A SEARCH STRATEGY

Being rules themselves, these heuristics can also generate subgoals, as do the rules described above.

For example, given

```
Goal(Fly(New York,London))
```

Heuristic1 would generate the subgoal

```
Goal(Distance_between(New
     York,London,??))
```

Heuristic2, given the same goal, would generate an equivalent subgoal. Thus, the single goal to determine the distance between New York and London would have two sources:

```
Goal(Fly(New York,London)),
     Heuristic1
Goal(Fly(New York,London)),
     Heuristic2
```

where a source is the combination of goal and rule that generates the subgoal.

The program could vote for any goal it created each time that goal was generated; that is, it could cast a vote in favor of a goal each time a source was added. Such a program would cause the system to strive to satisfy any goal that would allow it to evaluate or achieve a number of higher level goals. This is a domain-independent heuristic, as opposed to the previous heuristics, which are specific to domains in which flying or walking are relevant.

Using this heuristic would cause the inference engine to focus on establishing the distance between New York and London before focusing on walking, flying, or driving, each of which would have only one vote. After establishing the distance, which is presumably greater than both the riding and walking thresholds, the program votes for trying to fly, which dominates. If the distance were less than the walking threshold, a deciding vote would be cast in favor of trying to walk.

Such a strategy yields reasoning that more closely resembles our own intuitive approach to problem solving and results that are more in keeping with our commonsense expectations. The ability to apply any combination of heuristics to guide logical reasoning would dramatically assist in developing useful applications displaying more of what we normally think of as intelligence. ■

FOR MORE INFORMATION

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Mathematical Reasoning

A Prolog program uses heuristic methods to solve equations

Leon Sterling

[Editor's note: *This article is adapted from chapter 22 of* The Art of Prolog *by Leon Sterling and E. Y. Shapiro, MIT Press, 1986.*]

SUCCESSFUL MATH STUDENTS do not solve equations by blindly applying axioms of algebra. Instead, they learn, develop, and use various methods and strategies. In this article, I'll describe and present key sections of an equation solver, written in Prolog, that models this heuristic behavior. [Editor's note: *The complete source code for the program is approximately 12K bytes long and is available on disk, in print, and on BIX. See the insert card following page 304 for details. Listings are also available on BYTEnet. See page 4.*]

The program is a simplified version of PRESS (which stands for Prolog equation-solving system), a system developed by Alan Bundy and coworkers in the mathematical reasoning group in the University of Edinburgh's department of artificial intelligence (see reference 1). The original version of PRESS, written in 1976 by Bob Welham, was intended as a research tool for investigating methods of controlling search—which is, by the way, an alternate definition of *heuristic*.

What does equation solving have to do with searching? Quite a lot, when you construe it as a search for a sequence of correct algebraic identities to apply to an equation to find the value of an unknown.

The Use of Prolog

Prolog makes it easy to express tasks involving symbolic manipulation. As an example, let's consider the task of deciding whether a given symbolic expression is a polynomial in a given term. For instance, is the expression $a^2 - 3a + 2$ a polynomial in the constant a?

A constant is a polynomial in any term X. X is a polynomial in itself. Sums, differences, and products of polynomials in X are polynomials in X. So, too, is a polynomial raised to a nonnegative integer power, and the quotient of a polynomial by a nonzero constant.

By this informal definition, $a^2 - 3a + 2$ is a polynomial in a because it is the sum of the polynomials $a^2 - 3a$ and 2. The expression $a^2 - 3a$ is a polynomial because it is the difference of the expressions a^2 and $3a$, which are similarly shown to be polynomials in a.

The top level of a Prolog program for recognizing polynomials is shown in listing 1a. It is no more (and no less) than a translation of the informal rules given above. The relation scheme of the program is `polynomial(expression, term)`; the relation is true if `Expression` is a polynomial in `Term`. One thing that makes the code so natural is its declarative quality. For example, the fact `polynomial(X,X)` says that a term `X` is a polynomial in `X` itself. The rule

```
polynomial(Poly1+Poly2,X) :-
  polynomial(Poly1,X),
  polynomial(Poly2,X).
```

says that the sum `Poly1+Poly2` is a polynomial in `X` if both `Poly1` and `Poly2` are polynomials in `X`. The colon-hyphen sequence `:-` can be read as "if," and the comma inserted between relations as "and."

Notice that only what is true needs to be specified in the program. For instance, it is not necessary to state explicitly that sin x is not a polynomial in x. That fact is taken care of implicitly in Prolog's computational model.

Another property that makes Prolog good for this kind of program is that the language (in most implementations) lets programmers use the natural algebraic syntax for writing mathematical expressions. Internally, `A+B` is a structure `'+'(A+B)`, where `'+'` is an uninterpreted function symbol, but this is irrelevant to the programmer.

What Is Equation Solving?

We can describe equation solving syntactically. Given an equation

lefthand side = righthand side

in an unknown x, the object is to produce an equivalent statement

x = *righthand side 1*

where *righthand side 1* does not contain x. This final equation is our solution. Two equations are equivalent if one can be transformed into the other by a finite number of applications of the rules of al-

continued

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gebra, known as *rewrite rules* (see reference 2).

Our equation solver handles three categories of equations in one unknown, exemplified as follows:

$$\cos x(1 - 2\sin x) = 0 \quad (1)$$

$$x^2 - 3x + 2 = 0 \quad (2)$$

$$2^{2x} - 5 \times 2^{x+1} + 16 = 0. \quad (3)$$

In general, the program handles algebraic functions involving the operations +, −, ×, /, exponentiation to an integer power, and trigonometric and exponential functions. I'll briefly show how the solver handles each of the example equations.

The first step in solving equation (1) is factorization, which results in two simpler equations:

$$\cos x = 0 \quad (1a)$$

$$1 - 2\sin x = 0. \quad (1b)$$

A solution to either of these equations is a solution to the original equation.

An algorithmic method called *isolation* handles equations like (1a) and (1b), in which a single unknown occurs just once. The method repeatedly applies an appropriate inverse function to both sides of the equation until the single occurrence of the unknown is isolated on the left-hand side. For instance, the isolation algorithm handles equation (1b) as follows:

$$2\sin x = 1$$

$$\sin x = 1/2$$

$$x = \arcsin 1/2.$$

Equation (2) is a quadratic equation in x. Like any proficient high school student, the program solves it by a direct application of the quadratic formula.

Our equation-solving program uses a process called homogenization to solve equation (3). The aim of homogenization is to transform an equation involving logarithmic, exponential, or other transcendental functions into a polynomial in some term containing the unknown. For example, the key to solving equation (3) is to view it as a quadratic equation in 2^x:

$$2^{2x} - 5 \times 2^{x+1} + 16 = 0$$

$$(2^x)^2 - 10 \times 2^x + 16 = 0.$$

Solving by the quadratic method for 2^x gives two solutions of the form $2^x = Rhs$, where *Rhs* (the right-hand side) is free of x. Isolation techniques will then solve these equations for x.

Homogenization consists of four steps. The program parses the equation, collecting all maximal (i.e., not part of a larger term) nonpolynomial terms containing the unknown into an *offenders set*. For equation (3), the set would be $\{2^{2x}, 2^{x+1}\}$. The second step finds the reduced term—that is, the term in which the equation is a polynomial. The third step is to find rewrite rules that express each of the elements of the offenders set as a polynomial in the reduced term. Finding the rules guarantees that homogenization will succeed. The final step is performing the substitutions given by the rewrite rules.

The predicate `solve_equation(Equation,X,Solution)` is shown in listing 1b. It is the top-level relation of the equation solver. The relation is true if `Solution` is a solution to `Equation` in the unknown `X`. The predicate has four clauses, one for each of the four methods used in solving the three types of equations: factorization, isolation, polynomial analysis, and homogenization.

Each method has two parts: a condition testing whether the method is applicable, and the application of the method. I'll look briefly at how each method is implemented in Prolog.

Listing 1a: *Top-level code for recognizing polynomials.*

```
polynomial(X,X).
polynomial(Term,X) :-
    constant(X).
polynomial(Poly1+Poly2,X) :-
    polynomial(Poly1,X), polynomial(Poly2,X)..
polynomial(Poly1-Poly2,X) :-
    polynomial(Poly1,X), polynomial(Poly2,X).
polynomial(Poly1*Poly2,X) :-
    polynomial(Poly1,X), polynomial(Poly2,X).
polynomial(Poly/Term,X) :-
    polynomial(Poly,X), constant(Term).
polynomial(Poly^N,X) :-
    integer(N), N>=0, polynomial(Poly,X).
```

Listing 1b: *Top-level code for equation solving.*

```
solve_equation(A*B=0,X,Solution) :-
    factorize(A*B,X,Factors),
    remove_duplicates(Factors,Factors1),
    solve_factors(Factors1,X,Solution).
solve_equation(Equation,X,Solution) :-
    single_occurrence(X,Equation),
    position(X,Equation,[Side|Position]),
    maneuver_sides(Side,Equation,Equation1),
    isolate(Position,Equation1,Solution).
solve_equation(Lhs=Rhs,X,Solution) :-
    polynomial(Lhs,X),
    polynomial(Rhs,X),
    polynomial_normal_form(Lhs-Rhs,X,PolyForm),
    solve_polynomial_equation(PolyForm,X,Solution).
solve_equation(Equation,X,Solution) :-
    homogenize(Equation,X,Equation1,X1),
    solve_equation(Equation1,X1,Solution1),
    solve_equation(Solution1,X,Solution).
```

Factorization

Factorization is the first method the equation solver attempts. The applicability test is trivial: The right-hand side of the equation must be 0, and the left-hand side must have the form `A*B`. In Prolog, the test is accomplished through unification (i.e., pattern matching) of the equation to be solved with the term `A*B=0`.

If the test succeeds, the program invokes the factorization operations. Each factor of the left-hand side is equated to 0 and solved recursively by the use of `solve_factors`. Single solutions are found by `solve_factors`, with alternative solutions being given on backtracking. This is described by the first clause in listing 1b.

Isolation

The second method tried by the solver is the isolation of the unknown on the left-hand side of the equation. The second clause in listing 1b defines this method. The condition for applicability is that there be a single occurrence of the unknown X, checked by `single_occurrence`.

The isolation method proceeds to the predicate `position`, which calculates the position list of the unknown. Consider the equation $\cos x = 0$. The term $\cos x$ is the first argument of the equation, and x is the first and only argument in $\cos x$. The position list of x is therefore [1,1], as illustrated in figure 1a. Figure 1b shows the position list of x in the equation $1 - 2 \sin x = 0$, which is [1,2,2,1].

The next predicate in the isolation method is `maneuver_sides(N,Equation,Equation1)`. It ensures that the unknown X appears on the left-hand side of `Equation1`. The argument N is the head of the position list and indicates the side of the equation in which the unknown appears (1 = left, 2 = right). The code for `maneuver_sides` consists of two facts, covering the cases that X is on the left-hand or right-hand side of `Equation`:

```
maneuver_sides(1,Lhs=Rhs,
                      Lhs=Rhs).
maneuver_sides(2,Lhs=Rhs,
                      Rhs=Lhs).
```

The final stage of the isolation method makes the unknown the subject of the equation by repeatedly applying the rewrite rules until the position list is exhausted:

```
isolate([N|Position],Equation,
           IsolatedEquation) :-
  isolax(N,Equation,Equation1)
  isolate(Position,Equation1,
          IsolatedEquation).
isolate([],Equation,Equation).
```

The rewrite rules, or isolation axioms, are specified by the relation `isolax(N,Equation,Equation1)` where N is an argument position, `Equation` is an expression before applying the rewrite rule, and `Equation1` is the expression afterward.

Polynomial Analysis

The condition of the polynomial method, given by the third clause in listing 1b, is that both sides of the equation be polynomials in the unknown. If the condition is satisfied, the equation is converted to a polynomial normal form, and the polynomial solver goes to work.

The polynomial normal form is a list of tuples of the form (A_i,N_i), where each A_i is the coefficient of the corresponding, necessarily nonzero N_i. The tuples are sorted into decreasing order of N_i; for each degree i, there is at most one tuple. For example, the list [(1,2),(−3,1),(2,0)] is the normal form for $x^2 - 3x + 2$.

Reduction to normal form occurs in two stages:

```
polynomial_normal_form(Polynomial,
X,NormalForm) :-
  polynomial_form(Polynomial,X,
                        PolyForm),
  remove_zero_terms(PolyForm,
                        NormalForm).
```

The code for `polynomial_form` closely follows the code for `polynomial` given in listing 1a. For each clause used in the parsing process, a corresponding clause gives the resultant polynomial. For instance, the polynomial form of a term x^n is $[(1,n)]$, which is expressed by the clause

continued

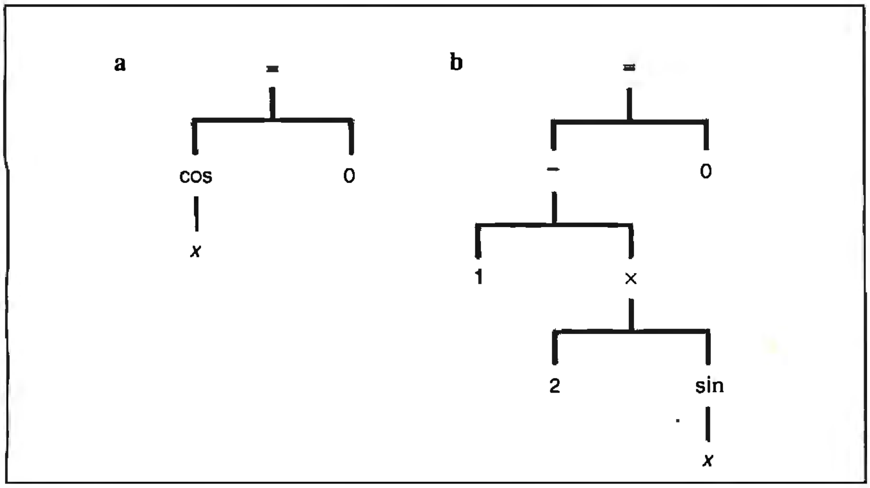

Figure 1: *A diagram showing how the position list for an unknown is generated.* **(a)** *In the equation cos x = 0, the position list for x is [1,1].* **(b)** *In the equation 1 − 2 sin x = 0, the position list for x is [1,2,2,1].*

```
polynomial_form(X^N,X,[(1,N)]).
```

Classical algorithms for handling polynomials apply to equations in normal form. The recursive clauses for `polynomial_form` manipulate the polynomials using simple algorithms to preserve this form.

Homogenization

The fourth clause in listing 1b shows the top-level homogenization logic. The original equation is transformed into a new equation in a new unknown. This new equation is then solved recursively, and its solution is used to obtain a solution to the original unknown.

Here's the code implementing the four stages of homogenization needed for solving equation (3) and similar equations:

```
homogenize(Equation,X,
           Equation1,X1) :-
  offenders(Equation,X,Offenders),
  reduced_term(X,Offenders,
               Type,X1),
  rewrite(Offenders,Type,X1,
          Substitutions),
  substitute(Substitutions,
             Equation, Equation1).
```

The code for `offenders` is similar to that for `polynomial`. A typical clause is

```
offenders(ExprA+ExprB,X,
                   Offenders) :-
  offenders(ExprA,X,OffA),
  offenders(ExprB,X,OffB),
  append(OffA,OffB,Offenders).
```

This clause states that the offenders set of the expression `ExprA+ExprB` is the result of concatenating the offender sets of `ExprA` and `ExprB`.

The code for offenders checks that there are at least two distinct elements in the offenders set. If there is only a single offender, homogenization will not be useful.

The predicate `reduced_term` finds a reduced term—that is, a candidate for the new unknown. Finding a reduced term proceeds in two stages: classifying the type of the offenders set, and finding a reduced term of that type.

```
reduced_term(X,Offenders,
                   Type,X1) :-
  classify(Offenders,X,Type),
  candidate(Type,Offenders,X,X1).
```

The program uses heuristic rules to classify the offenders set. In the example equation (3), the offenders set is of type exponential: All elements in the offenders set have the form A^B where A does not contain the unknown but B does.

Heuristic knowledge is also the basis for finding a suitable reduced term: If all the bases of the exponential terms in the offenders set are the same, say, A, and each exponent is a polynomial in the unknown X, then A^X is a suitable reduced term:

```
candidate(exponential,Offenders,
                    X,A^X) :-
  base(Offenders,A),
  polynomial_exponents(Offenders,
                      X).
```

The next step checks that each member of the offenders set can be rewritten in terms of the chosen reduced term. This involves finding a suitable rewrite rule. In this case, the applicable rules are

```
homogenize_axiom(exponential,
           A^(N*X),A^X,(A^X)^N).
homogenize_axiom(exponential,
           A^(X+B),A^X,A^B*A^X).
```

Extending the Solver

The equation-solving methods are readily adaptable to similar symbol-manipulation tasks, such as solving inequalities, proving identities, and solving simultaneous equations. Adding these capabilities is primarily a matter of adding rules covering the appropriate symbols.

An interesting extension of PRESS (the large system from which the minisolver is derived) is the learning program LP, written by Bernard Silver (see reference 3). Starting with a subset of the methods of PRESS, LP was given worked examples of how to solve equations. LP analyzed the worked solutions and was able to build a new equation-solving method to solve similar equations. Essential to LP's success was the logical nature of the equation-solving program—for example, the distinction between testing for methods applicability and the execution of a method.

The range and variety of extensions to PRESS illustrate the importance of using a logic programming language like Prolog for heuristic applications. ■

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Neural-Network Heuristics

Three heuristic algorithms that learn from experience

Gary Josin

THE ACCELERATING PACE of high-performance hardware development and the emergence of parallel-machine architectures signal the need for a new approach to designing software. We need a new software paradigm that cannot only take advantage of hardware advances but also can deal with circumstances the software's writer could not have foreseen.

What we need is software that can learn from experience. A concept that lends itself well to the heuristics of learning from experience is the neural-network model. Several algorithms have been developed to test the validity of neural-network heuristics. This article explores three of these algorithms. [Editor's note: *For an explanation of another of the neural-network algorithms, see "Back-Propagation" by William P. Jones and Josiah Hopkins on page 155.*]

Before delving into the algorithms, however, let me explain why the neural-network paradigm holds much promise.

Computational Richness

When performing intelligent information processing, such as image recognition, language comprehension, or combinatorial optimization, the human brain outperforms even the fastest digital computer. This is primarily because of the fundamental difference in information-processing capabilities of digital computers and human brains.

Digital computers can be programmed for intelligent tasks. The problem is that the algorithmic solution to many information-processing tasks is far too complex to be programmed.

But that's not the only problem. Even if a particular application has a clear and concise solution, many algorithms are too computationally intensive to allow a digital computer to find a solution in any reasonable period of time.

The computational richness of the human brain comes from its large number of "living neurons" that are connected to each other by a complex network of synapses. Neural-network designs use the structure of the human brain to try to emulate the way intelligent information processing occurs within a living brain.

In software simulations, the basic structure of a neural network is very simple. It consists of an array of elements usually called "neurons," interconnections between these neurons, and some I/O scheme. The intelligent information properties of the network arise from the topology of the network and in the learning rules of the neurons.

The topology of a neural network describes factors such as how many interconnections there are for each neuron; that is, is each neuron connected to a few other neurons, to many other neurons, or to all other neurons in the network? If a neuron is not connected to all other neurons, does it connect to its nearest neighbor neurons, to distant neurons, or to some combination of near and distant neurons? Finally, and more importantly, what is the neural network trying to internally represent within a particular topological structure?

The learning rules for the neurons describe how each neuron interprets the information coming in from all the neurons connected to it and, on the basis of that interpretation, what signal to distribute to the rest of the network. There are many different learning rules based on a number of factors, such as dependence on the previous state of the neuron, stable or varying thresholds, and the particular functions used to sum the input signals.

A model of a neural network uses a particular topology, a type of neuron, and a learning rule for the interactions and interrelations of its fundamental constituents—the neurons and their connections. Particular models give a description of a neuron's actual input and output and the mapping between the input and output.

Soviet mathematician A. N. Kolmogorov has proved a theorem (see reference 1) that neural-network models can learn to approximate any continuous mapping—while minimizing error in the mapping in a least-mean-square sense—based only on the example mapping. In fact, a network can even learn to adapt to unpredictable changes in its inputs.

If a particular neural-network model's computational capabilities are more effective at performing information-processing operations than computer-based approaches, this makes it practical for the construction of neural-network machines, regardless of whether neural networks actually emulate the human brain.

continued

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Neural networks process information in novel ways. In fact, given a threshold number of connections between a set of simple neurons, a form of *self-organization* takes place, and from this organization collective computational properties emerge, such as association, generalization, differentiation, preferential learning, optimization, and fault tolerance. The use of these properties holds promise for developing solutions to problems that have intractable or unknown algorithms or are too computationally intense. The above properties are evident in the three neural-network models described and illustrated below.

General Equation

The different models and combinations of models of neural networks can be derived from the following equations:

$$dU(i)/dt = G[J(U(i)), \{Sj\}T(i,j)f(U(j)] \quad (1a)$$

where

$$dT(i,j)/dt = g(T(i,j),U(i),U(j)). \quad (1b)$$

U(i) is the input to neuron (i); G() is a function that describes the output of neuron (i); {Sj} denotes the sums over the j interconnections to neuron (i); J() is a function describing the coupling of a neuron to itself; f() is a function that describes the input from connection (j) to neuron (i); T(i,j) is an interconnection value between neuron (i) and neuron (j); and g() is a function that describes how to assign an interconnection value.

Particular network models and their heuristics can be derived from this general neural-network equation. Here is a brief description of the three models under examination:

- The *associative memory* model exhibits many of the computational capabilities of neural networks, such as association. This model can be used for simple visual processing (see reference 2).
- The *optimization* model offers solutions to very difficult combinatorial optimization problems, such as the well-characterized traveling salesman problem (see reference 3).
- The *self-organization* model is effective for dealing with problems that have a complicated or impossible-to-define algorithm, and it can be used for robotic control (see reference 4).

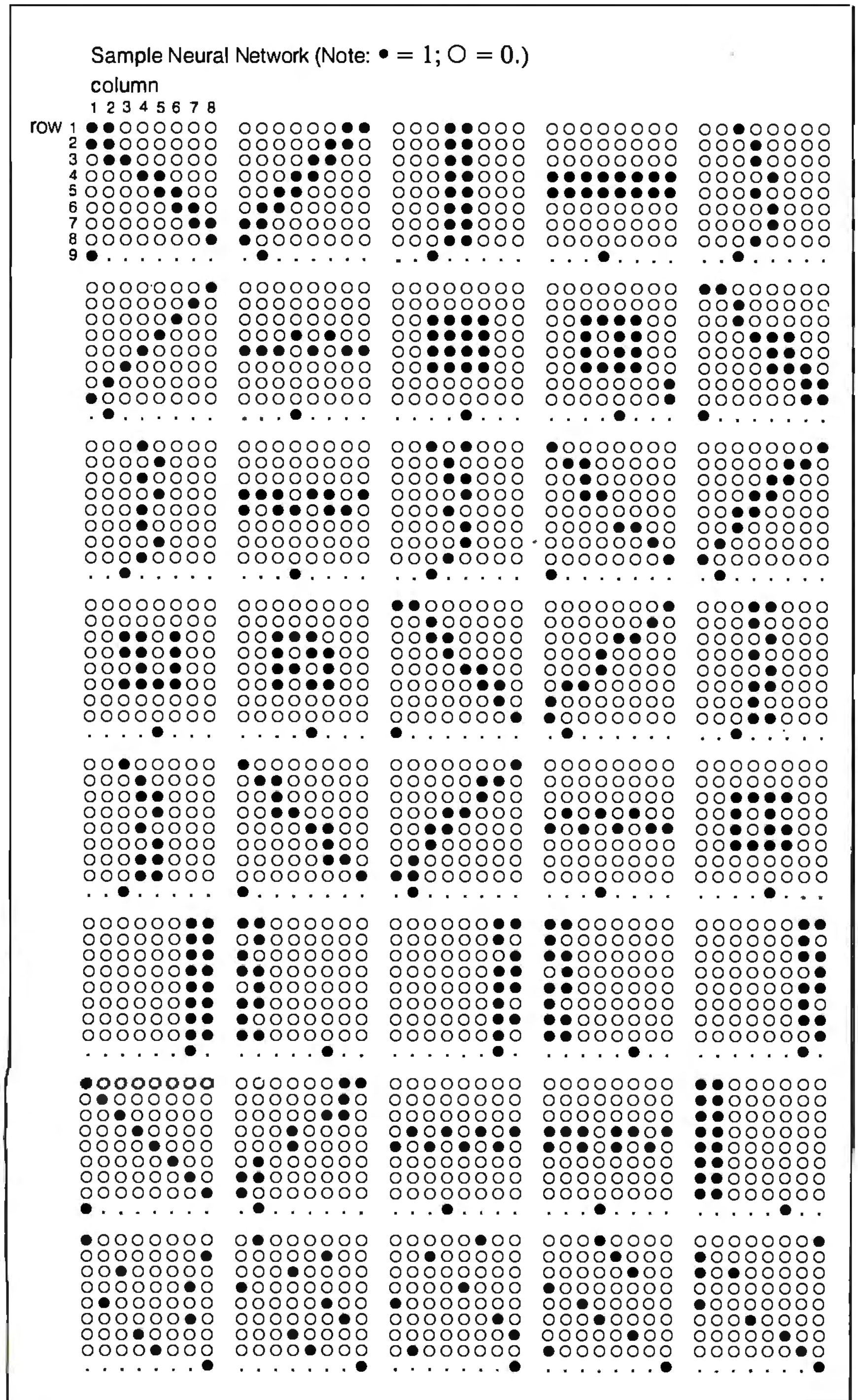

Figure 1: *The original patterns for a sample neural network designed to illustrate the associative memory property. (Note: • = 1; O = 0.)*

The Associative Memory Model

For an example of a simple visual-processing application and an introduction to the computational properties of a neural network, consider the set of patterns in figure 1. These patterns constitute a database of simple "primal" images. These images are a simple list of eight rows of eight numbers with values of 0 or 1. The ninth row contains a single 1.

The ninth row categorizes the patterns; for example, the pattern in the top left-hand corner of figure 1 has a single 1 in the first column of row 9, whereas the pattern directly beside it to the right has a 1 in the second column of row 9. A 1 in the first column of row 9 categorizes a pattern as a top left- to bottom right-hand corner diagonal line. A 1 in the second column of row 9 categorizes a pattern as a top right to bottom left diagonal. The other patterns are similarly categorized. This process of categorizing patterns is a case of supervised learning. A teacher

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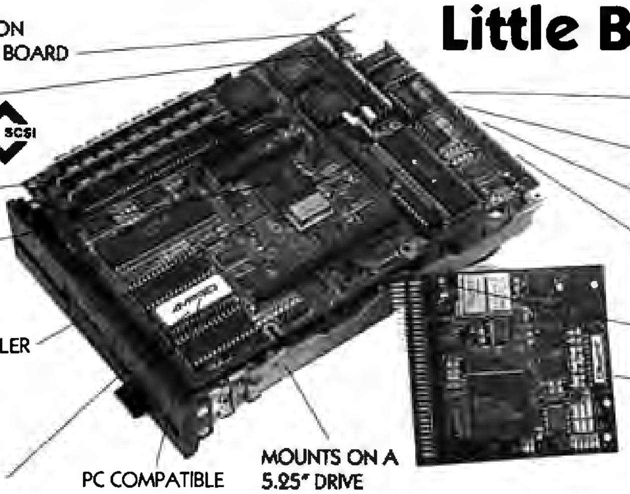

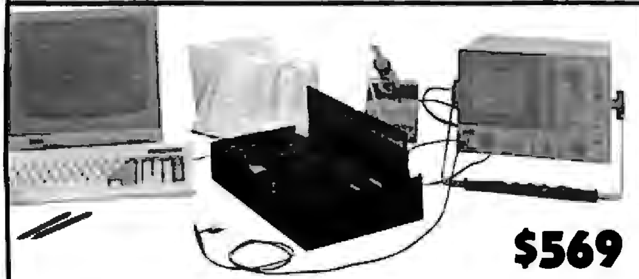

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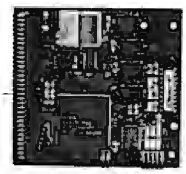

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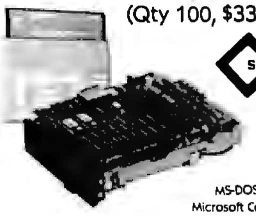

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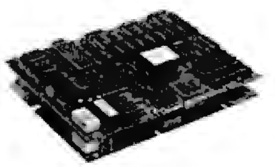

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has to categorize the patterns.

The associative memory model can be configured as an associative "memory" to encode/decode these primal images. If each neuron represents a bit (1 or 0), a network of 72 neurons can map this particular set of patterns in the form of an N-by-N connection matrix T(i,j). Then, when presenting a pattern U(i) as input to the neurons, the network evokes the desired memory behavior.

For this particular application, the associative memory model uses two-state neurons. The neurons' outputs take on values of either a 1 or a 0, depending on the inputs from all other interconnected neurons. The total input to neuron (i) is then

$$E(i) = \text{total input to } (i) = \{Sj\}\,\{Sl(i)\}T(i,j,l(i)),$$

where {Sj} denotes the sum over all other neurons, and {Sl(i)} denotes the sum over l(i) and defines the length of the memory of neuron (i).

Given the total input, neurons change their output according to a threshold rule:

$$G[E(i)] = 1 \text{ if } E(i) > Th(i),$$
$$G[E(i)] = 0 \text{ if } E(i) <= Th(i),$$

where Th(i) is the threshold of neuron (i).

This model uses a modified Hebbian learning rule (see reference 5) that describes how patterns are mapped between neuron (i) and neuron (j):

$$T(i,j,l(i)) = (2U(i,l(i))-1) *(2U(j,l(i))-1).$$

For N two-state neurons, equations (1a) and (1b) then simplify to

$$U(i) = G[\{Sj\}\,\{Sl(i)(2U(i,l(i))-1) *(2U(j,l(i))-1)U(j)].$$

This network operates in two phases. In the first phase, the 40 patterns in figure 1 are input to the network to assign the connection matrix T(i,j) between the neurons. In the second phase, the performance of the network is tested by presenting patterns to the input neurons. The N outputs then describe how the network performs information processing.

Figure 2 shows how the network performs on a set of input patterns in the second phase after the connection matrix T(i,j) has been assigned. The sequence shows the mapping of the network after entering a particular input pattern. The input patterns in this sequence were selected so that they would get progressively further away from resembling the original pattern shown in figure 1. Figure 2 also shows the total excitation on the neuron that categorizes that particular pattern. As the figure shows, the categorizer neuron is less excited as the input pattern to the network gets further away from resembling an original pattern. In this way, a categorizer neuron's excitation is a measure of how close an input pattern is to a particular original pattern.

Figure 3 shows how a network performs computation on confusing and ambiguous input patterns. The last pattern in the sequence shows how the network has responded to a confusing input pattern that was constructed from 60 percent of one pattern and 40 percent of another. The network maps this confused pattern to the closest original pattern.

Figure 3 also shows the network's performance for ambiguous input patterns

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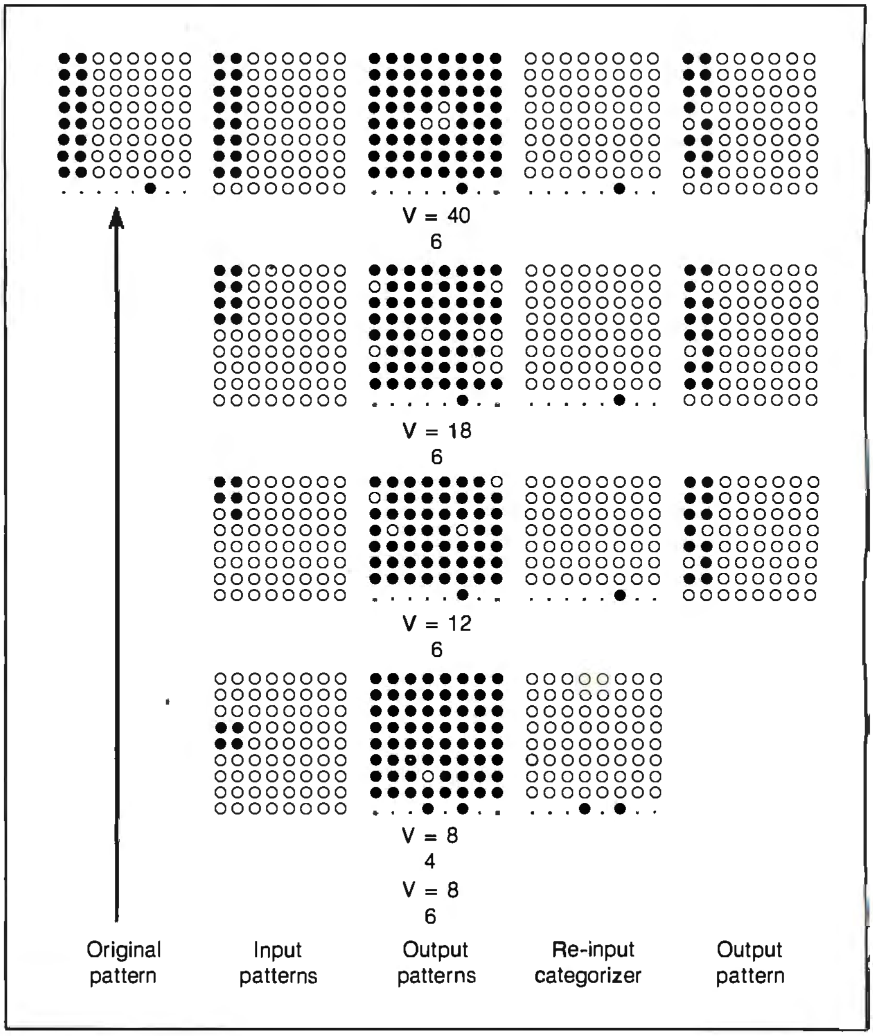


Figure 2: *Inputs to the original pattern of the network produces output patterns and an input categorizer.*

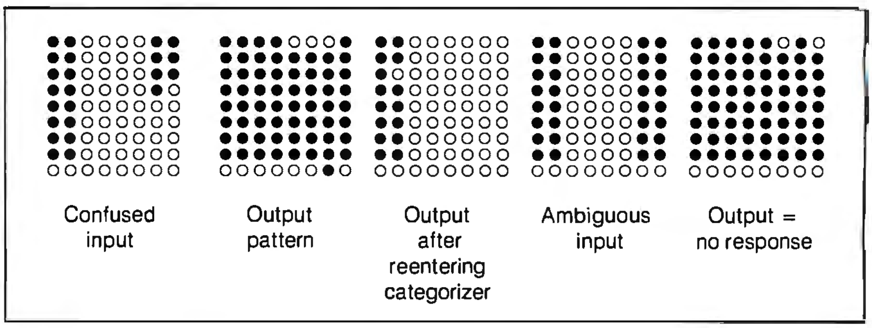
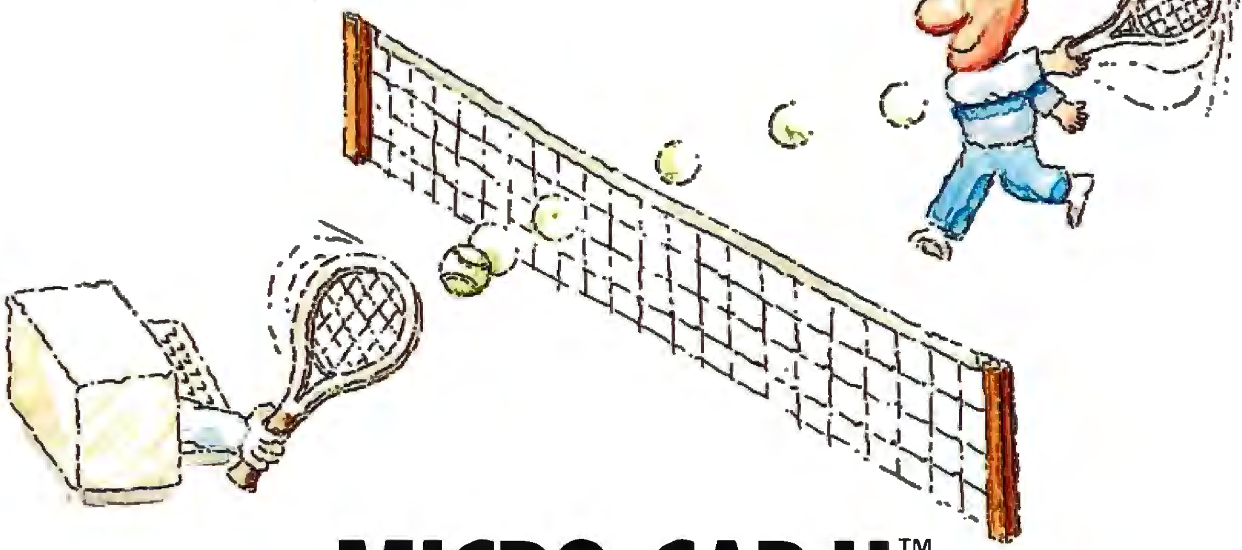


Figure 3: *The output patterns generated by confused and ambiguous input patterns.*



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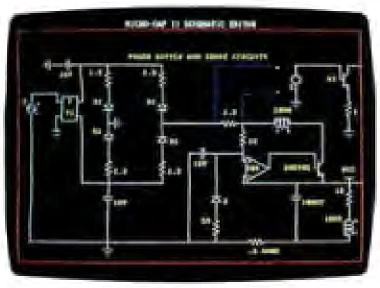

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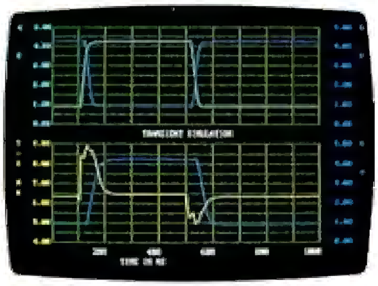

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that are constructed from 50 percent of one pattern and 50 percent of another. The network matches this ambiguous input to no response. If the network had been trained on one of the patterns more often than the other, it would have developed a preference for that particular pattern. This is called *preferential learning.*

Since input patterns are stored in a distributed fashion throughout the network, a large percentage of neurons and/or their interconnections can be destroyed, and the network can categorize input patterns as before. This gives the network *fault tolerance.* When the associative memory model is minimally connected to map only one pattern, it acts like a filter and can *differentiate*. In other words, the network can discriminate that particular input pattern from all other input patterns.

On the other hand, as the network comes closer to being fully connected, the network can map or *associate* variations of particular patterns.

The Optimization Model

As an example of a neural network that could produce solutions to optimization problems, consider the map of locations in figure 4. For N locations on a map, calculate all closed paths that visit each location once, then pick that combination of paths that produces the overall shortest path length. There are N! possible solutions, and this number gets large very fast. For example, for 30 locations there are 10^{30} possible paths. On a present-generation computer, this task is computationally intensive. This is an example of a problem that has a well-characterized algorithmic solution. The goal for this model is to find a less intensive solution.

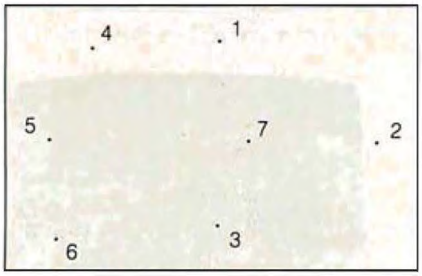

Figure 4: *The seven map locations illustrating the well-known traveling salesman problem.*

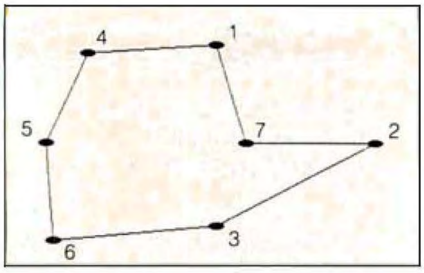

Figure 5: *A solution for the traveling salesman problem, as found by a neural network using the optimization heuristic.*

This model optimizes for path minimization and uses an equation for dU/dt as follows:

$$dU(i)/dt = -U(i)/R(i)C(i) + [Sj]T(i,j)f(j,U(j))/C(i) + I(i),$$

where

- U(i) is the input to neuron (i),
- I(i) is the current injected into neuron (i),
- RC is the time constant of the neuron (i), and the resulting U(i) is processed by G[U(i)] = (1 + tanh(A(U(i) - Th(i))))/2, where G[U(i)] is the output of the neuron, Th(i) is the threshold of neuron (i), A is the gain.
- T is the connection matrix defined from the learning rule

$$T(i,j) = -A\,delta(x,y)(1 - delta(i,j) - B\,delta(i,j)(1 - delta(x,y)) - C - D\,d(x,y)(delta(j,i+1) + delta(j,i-1)),$$

where delta(i,j) = 1 if i=j; otherwise, delta(i,j) = 0; and A, B, C, and D are coefficients that are general constraints for any particular problem of this type.

The first two terms of the expression for T(i,j) guarantee only one visit to each location and that a location can be in only one position in the tour. The fourth term is a constraint that controls which of the N! possible final states is the best path.

Figure 5 shows a solution found by the optimization model. The network found near-best solutions to this problem—not the exact solution.

In many situations, finding one of the best paths very rapidly is better than computing the optimal solution to the problem.

The Self-Organization Model

The final model is an example of a neural network that can learn to approximate a mapping for robotic control strategy based only on randomly sampled inputs from a two-dimensional space. This model uses neurons that operate in the linear regime as follows:

$$U(i,t+1) = [Sj](T(i,j)U(j,t)),$$

where the learning rule evolves the system by the following equation:

$$dT(i,j)/dt = a(t)[U(j,t) - T(i,j,t)], \quad (2)$$

depending on whether neuron (i) is in the topological neighborhood of the neuron that best matches a particular input U(j). During the learning phase, the connections T(i,j) are adjusted so that their values form a topological image of the inputs. When a position U(j) is input to the network, the T(i,j) value that is maximally active for that particular input acts like an image of that input.

Consider a robotic arm that is moving around randomly in a two-dimensional plane. The arm is a line segment that can change its angle and length. As the arm moves in the plane, its end effector is located to a random position in the *x,y* plane. The connections are thought of as internally representing 400 coordinate pairs in the plane. A randomly selected coordinate pair from the arm's location sensor is fed as input to the network. The connection that becomes the most active is considered the image of that particular location. This connection to a particular neuron defines the topological neighborhood.

As described by equation (2), once the neighborhood is defined, all of the neurons within it change their connection strengths by an amount directly proportional to how far away it is from the randomly selected coordinate pair. After the robot arm has sampled a sufficient number of uniformly distributed coordinate pairs over the two-dimensional surface, the network's connections become ordered according to their mutual similarity. The end result is that a particular neuron becomes sensitive to a particular connection that in turn becomes most active in response to a particular randomly sampled coordinate, forming an image of the two-dimensional space.

Figures 6 to 10 show how well the network forms the image of two-dimensional space as the number of randomly selected coordinate pairs used to produce the mapping increases. Notice that as more points are sampled, the lattice of lines is beginning to show the emergence of the topology-conserving property of the connections. The connections converge to form an ordered map of a two-dimensional space. In figure 10, a well-formed map has emerged.

Figure 11 shows a plot of random coordinate pairs that are totally different from any of the pairs that were used in forming the topological map. These previously unseen positions are generalized as a nearest-neighbor match.

Neural-Network–Based Systems

Self-organization lets neural-network-based systems adapt to unpredictable changes in their environment. The network learns directly from its environment so that no extra constraints are required.

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Consequently, this property allows desired functionality independent of any knowledge of the physical parameters of a particular system. A neural system has no knowledge of equations, nor does it learn any.

Self-organization enables neural-network-based systems to make up for inaccuracies in mechanical structures and inaccurate sensor readings as they naturally degrade. Present-day systems that

continued

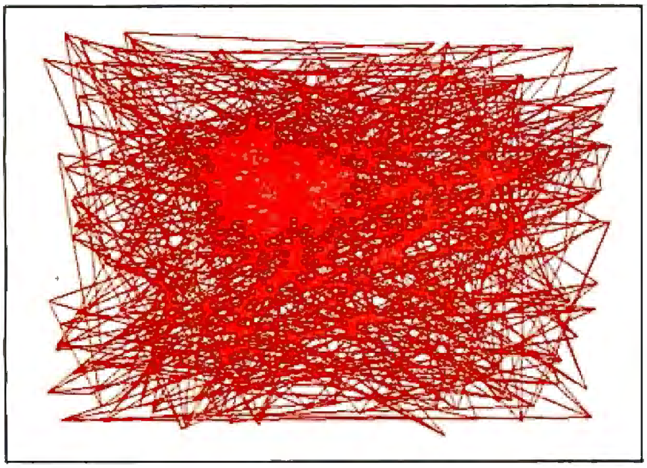

Figure 6: *A map of the two-dimensional space for a sample robotic-arm matrix, plotted using randomly selected coordinate pairs.*

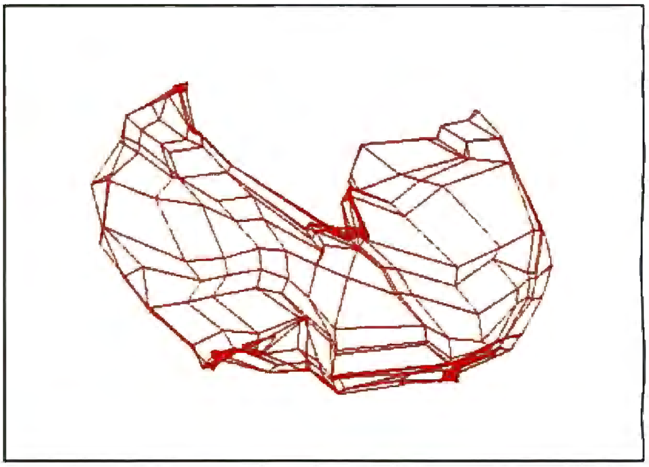

Figure 7: *The matrix begins to define a two-dimensional surface as the number of points increases. Here, the number of defined points is 50.*

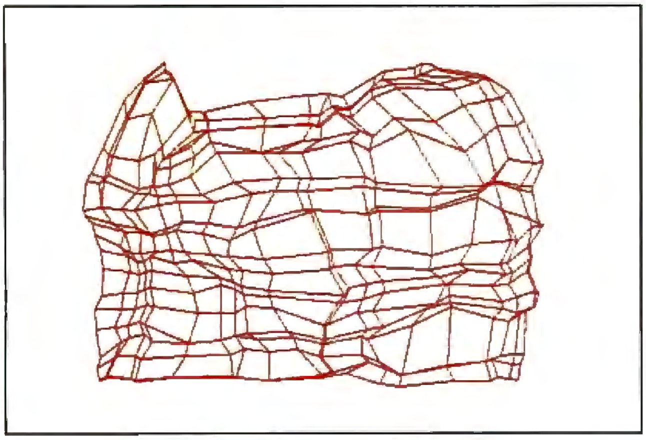

Figure 8: *With 250 points defined, the matrix nearly has a recognizable shape.*

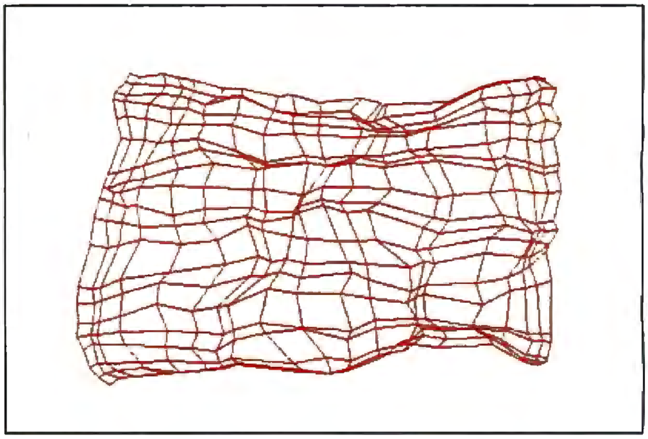

Figure 9: *The matrix still looks irregular with 500 points defined.*

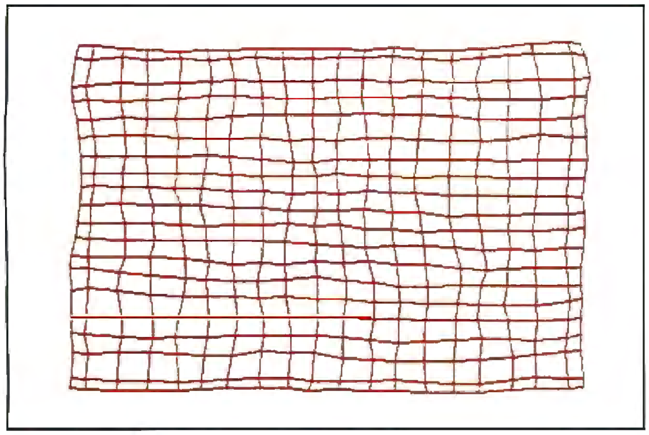

Figure 10: *It requires the specification of 5000 points to clearly define the matrix.*

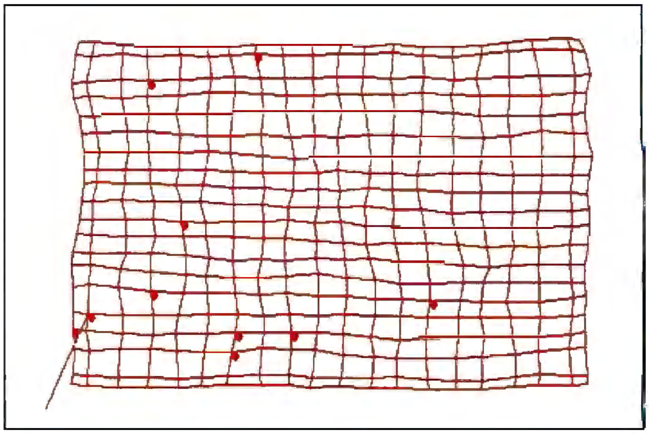

Figure 11: *After the matrix is defined, it is possible to place points within the two-dimensional space of the matrix that are different from the points used to define the area.*

use predefined algorithms are insufficient in situations that do not have accurately known structures or have changed due to system malfunctioning. Predefined adaptive algorithms do exist, but they use iterative least-squares approximations to deal with the problem of changing situations.

These algorithms are too computationally intensive for use in real-time applications, since such schemes require cumbersome lookup tables and prior knowledge. Furthermore, neural networks are intrinsically fault-tolerant, letting neural circuits survive orders of magnitude longer than present-day circuitry. In fact, neural-circuit technology should be able to make up for propagation delays, jitter, and noise, making systems virtually fail-safe.

The self-organization property offers a method of dealing with unexpected situations that cannot be described mathematically. An example is the management of real-time databases encountered in knowledge-based applications for complex industrial-control strategies, such as making decoding decisions based on the present status of the system.

In the context of neural-based robotic-control strategy, self-organization will enable control with inaccurately known mechanical structures, or even if the mechanical structure has changed from mechanical deformation from bending, sliding, or recoil.

Furthermore, if a neuron's excitation represents the rate of contraction of particular "muscle groups," then given the coordinates of a previously unseen position in space, the neurons' excitations—their rate of contraction—determine where in space the arm will end up. With this type of self-organization, numerical stability is guaranteed.

The optimization property offers a method of finding solutions to problems that are computationally explosive. Indeed, neural networks allow for a method of dealing with the "combinatorial explosion" encountered in path minimization. For instance, researchers have shown that the optimization property can be used to perform a number of difficult tasks in computer vision, such as computing motion and brightness perception, surface interpolation, and localizing edges. Implementation of these properties will become very important for real-time vision systems that will be used in a variety of applications, such as adaptive flight-control systems.

Combinations of neural-network properties will become even more powerful. For example, a combination of self-organization and optimization will be useful for robotic-control path minimization and collision avoidance, and it will be the next step for the simplest of real-life applications. This combination will make robot motion graceful.

Although we have a long way to go to understand how the human brain actually works, it is clear that this line of research will ultimately increase our understanding of fundamental functions of human intelligence and perhaps lead to the first truly intelligent machines. ■

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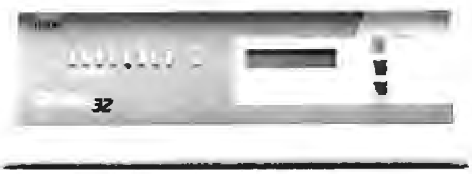
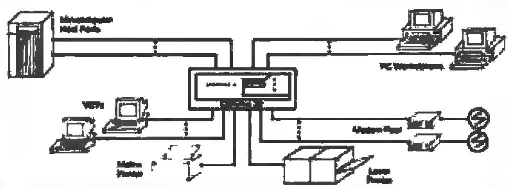


Universal Connectivity



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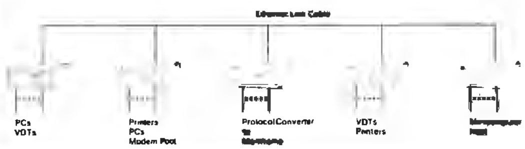

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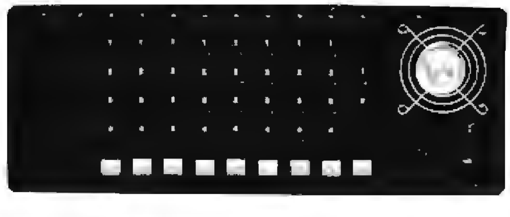

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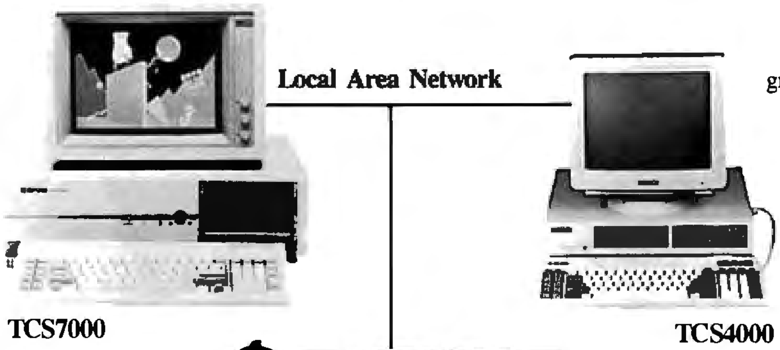

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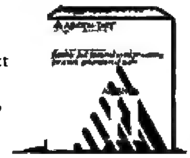

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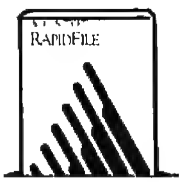

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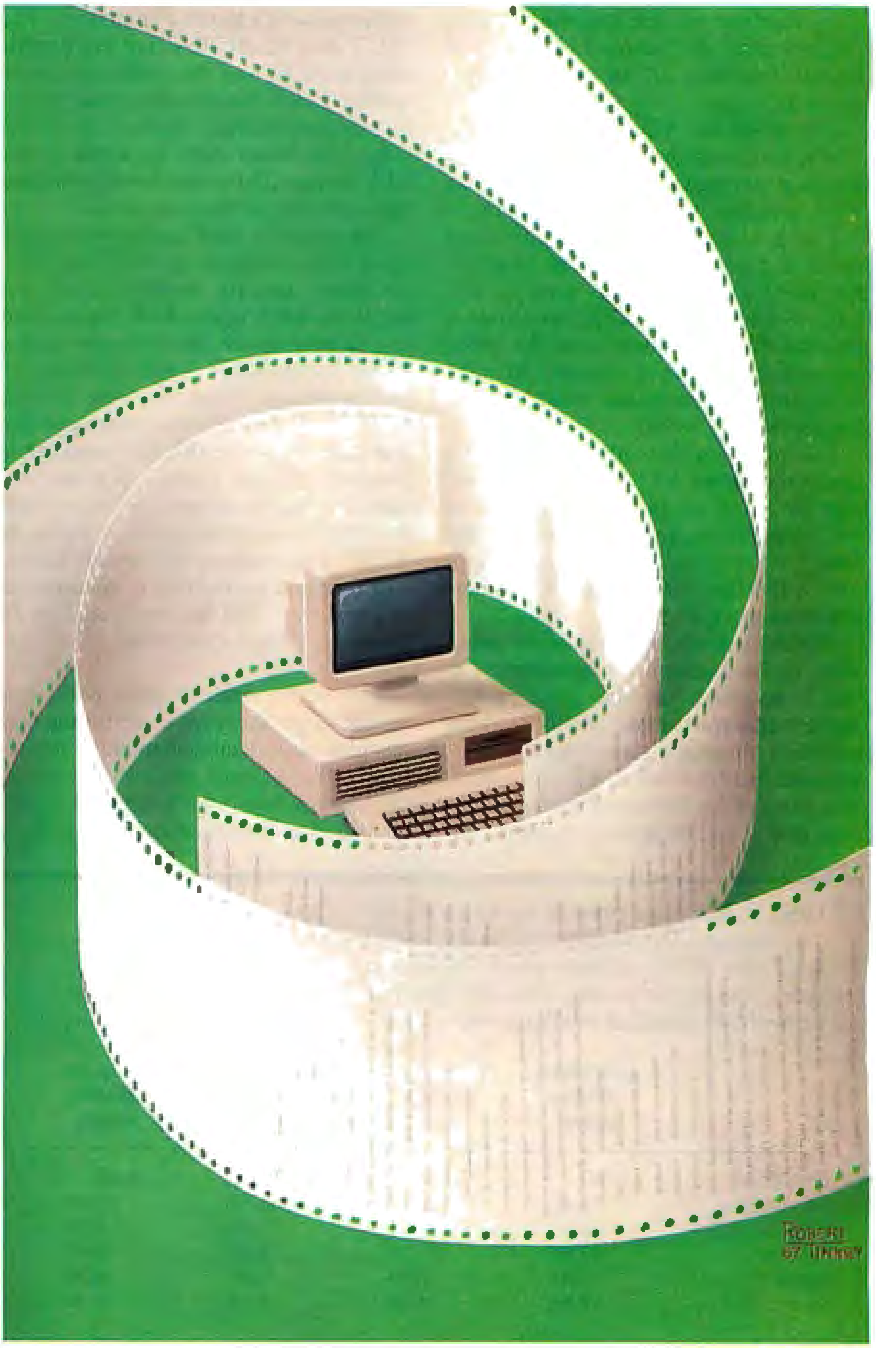


The ALR 386/2 is a second-generation 80386-based computer from Advanced Logic Research, one of the first companies to introduce an 80386 machine. The 386/2 differs considerably from the first ALR 386 in its redesigned motherboard and lower price. [Editor's note: *For a review of the ALR 386, see "The ALR Access 386 and the Compaq Deskpro 386" by Stanley J. Wszola and Curtis Franklin Jr. in the February BYTE.*]

I reviewed the ALR 386/2 Model 40, which has 2 megabytes of 80-nanosecond RAM, a 40-megabyte hard disk drive, an EGA graphics adapter and monitor, a 1.2-megabyte floppy disk drive, and serial and parallel ports. The machine has eight expansion slots (two 32-bit, four 16-bit, and two 8-bit), and uses a Phoenix BIOS. All models of the 386/2 come with a standard 101-key AT-style keyboard. The suggested retail price of the Model 40 is $3990.

The lowest priced member of the 386/2 line is the Model 10, which has 1 megabyte of RAM on the motherboard, no hard disk drive, and no graphics. The Model 10 is priced at $1990, making it one of the first 80386-based computers that costs less than $2000.

The Model 40 is available in either desk- or floor-mount configuration. The unit I reviewed was the floor mount. Some companies make a floor-mount model by slipping a stand over the case; with the ALR, the case *is* the floor stand. You can use the floor-mount model on a desk only if you position it on the far left edge of the desk, letting the stand hang over the edge.

Two major changes differentiate the 386/2's hardware from that of the original 386. Both are the result of using a new motherboard. The original ALR 386 used the Intel motherboard, which had an Intel proprietary 32-bit slot design for high-speed memory expansion. The 386/2 uses 32-bit slots that are proprietary to ALR. The most striking feature of these slots is that they are physically indistinguishable from standard AT 16-bit slots. You locate them by virtue of the *ALR special 32-bit slot* legend stenciled between them on the motherboard.

The original Intel motherboard also came with a socket for an 80387 math coprocessor. Actually, the 80387 would fit, but it wouldn't work. ALR has avoided this problem in the 386/2 by providing a socket for an 80287 (supplied on the review machine). There is a bare spot on the motherboard that is just the right size and shape for an 80387, but no socket is provided. [Editor's note: *ALR has announced that it will provide an upgrade for 386/2 owners who wish to install an 80387. The company was unable to provide cost and availability of the upgrade at press time. You can reach ALR at 10 Chrysler, Irvine, CA 92718, (714) 581-6770.*]

One of the other improvements Advanced Logic Research made for the new machine is in documentation. In the review of the original ALR 386, some of the harshest words were reserved for the manual. The user's manual for the 386/2 is a vast improvement. It is easy to read, well-organized, and has meaningful illustrations. The user's manual still would not be mistaken for a technical guide, but it is complete enough to let you get started with the computer.

The ALR 386/2 does not come with an operating system. For this review, I used PC-DOS 3.3. The 386/2 does come with software, however. ALR is now bundling a copy of Control-386, from Phoenix Technology, with the 386/2. This software brings many advantages to the machine; the most impressive is the dramatic increase in the performance of the hard disk drive. According to the Coretest software I used to measure the speed of the hard disk drive, the data transfer rate of the controller jumped from 184.2K bits per second to 434.4K bps after the installation of Control-386 version 1.1. For comparison, the Compaq Deskpro 386 has a disk transfer rate of 165.1K bps, and the IBM PS/2 Model 80 has a disk transfer rate of 456.8K bps.

Control-386 also provides disk caching, loading of ROM BIOS and EGA BIOS into 32-bit RAM, and disk interleave optimization. In addition to all these performance benefits, the software offers virtual 8086 environments, 32-bit emulation of EEMS and EMS memory, and complete emulation of the 80286. The emulation of 80286 functions includes undocumented functions, such as LOADALL, that are frequently used in virtual-mode software for the IBM PC AT.

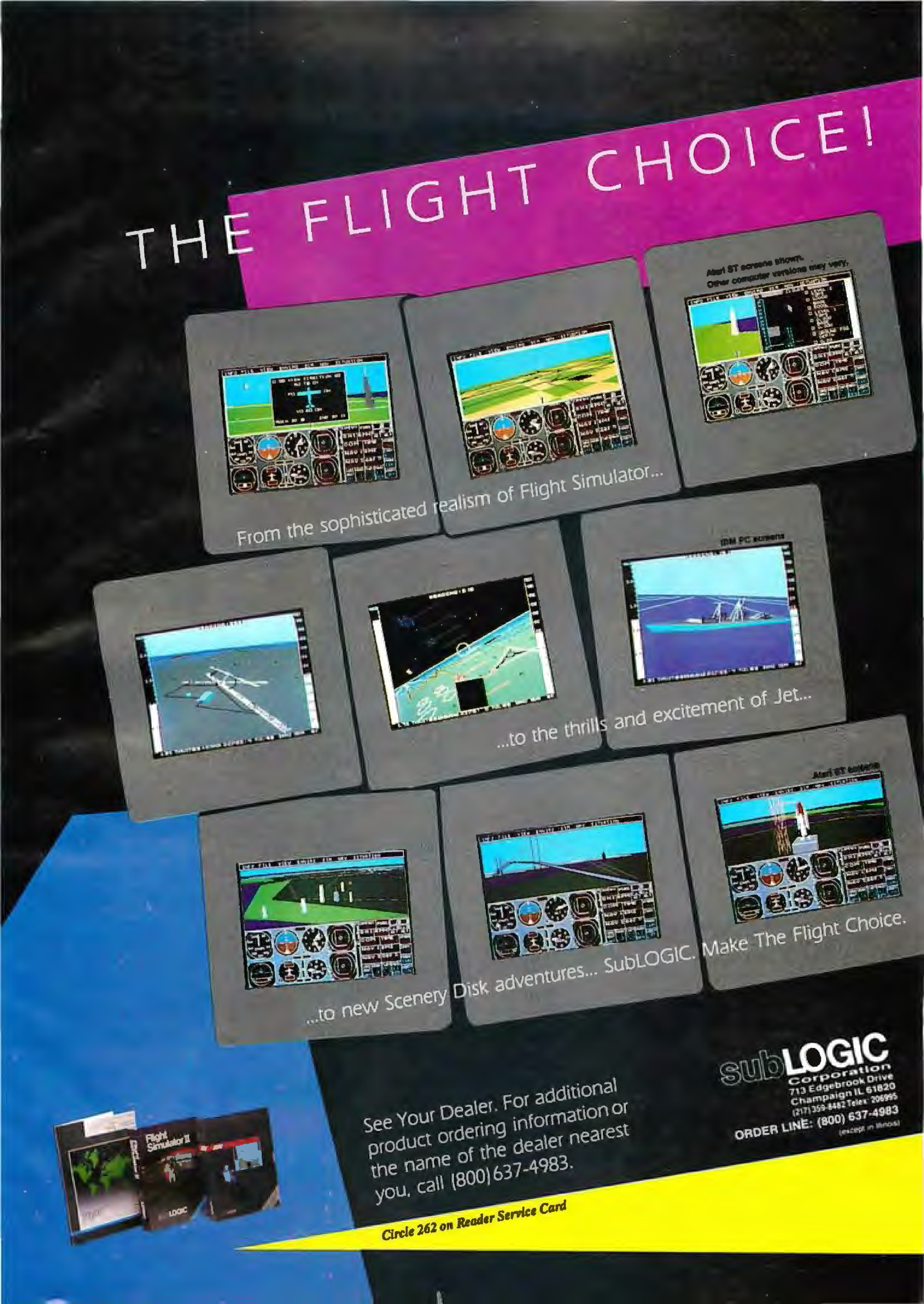
The major performance boost in the 386/2 is the result of the new hard disk controller and the Control-386 software. The 100- by 25-cell spreadsheet that the original ALR 386 loaded in less than 22 seconds is loaded in less than 2 seconds by the 386/2. (For other benchmark results, see table 1.) While the boost in hard disk performance does not show up in most benchmarks, it does have a great impact on most operations that a user would perform.

In all, ALR has taken the very fast 80386 and coupled it with a very fast hard disk system. The result is a computer that should satisfy the performance needs of all but the most specialized technical applications that demand the power of workstations.

—Curtis Franklin Jr.
Associate Technical Editor

Table 1: *Benchmark results for the ALR 386/2. These C benchmark programs are described in "A Closer Look" by Richard Grehan in the September BYTE. All times are in seconds, except for the Dhrystone, which is in iterations per second. The ALR 386/2 benchmarks were run with Control-386 installed on the system.*

	ALR 386/2 10-MHz 80287	Compaq 386 8-MHz 80287	Compaq 386 16-MHz 80387	Model 80 16-MHz 80387
Dhrystone	3283	3748	3748	3626
Fibonacci	64.66	53.12	53.13	57.26
Float	5.2	6.8	1.43	1.62
Savage	17.97	21.53	8.95	9.49
Sieve	7.41	5.99	5.98	6.45
Sort	8.55	5.58	5.58	7.74



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The Macintosh II

Bruce F. Webster

A powerful 68020 CPU, NuBus slots, and color, with a few compatibility problems

Back in February 1984, I bought a Macintosh computer right off the shelf. It had a 512- by 384-pixel monochrome display, 128K bytes of RAM, 64K bytes of ROM, a single 400K-byte floppy disk drive, and a 68000 CPU running at 7.83 megahertz. It had no expansion slots, no means of expanding RAM, and no external disk drives or hard disks available. It cost me around $2500, and there were only three software packages available for it: the MacPaint/MacWrite combination from Apple, Microsoft Multiplan, and Microsoft's BASIC interpreter.

Now, more than three years later, I have a Macintosh II sitting in my office. It has a 640- by 480-pixel gray-scale display, 1 megabyte of RAM, 256K bytes of ROM, an 800K-byte floppy disk drive, a 40-megabyte internal hard disk drive, an Apple video card with 256K bytes of video memory, and a monochrome monitor. It has six NuBus expansion slots. It can be expanded to many megabytes of RAM via both the motherboard and the NuBus slots, and a variety of disk drives (both internal and external) are available. This system costs around $6267, and there are hundreds of software packages available for it.

The Macintosh II System

The Macintosh II has already been covered extensively in the product preview that appeared in the April issue of BYTE. But I'll give a quick description of it here.

The Mac II is a modular computer system built around the 68020/68881 chip set from Motorola running at 16 MHz, and the Macintosh Toolbox and operating system routines from Apple. A full 32-bit data path is used for memory and bus access, as opposed to the 16-bit data path and 24-bit bus on the other Macintosh systems. The combination of doubled clock rate and doubled data path give roughly a fourfold increase in performance over the Mac Plus.

Since the computer has no standard video system, you can select the video display you want. Apple sells a Macintosh II video card with 256K bytes of RAM that supports 640- by 480-pixel resolution with four bits per pixel, giving you 16 colors (or gray shades) out of a palette of 16 million. A video card expansion kit adds 256K bytes of RAM to increase the pixel depth to 8 bits (1 byte per pixel), yielding 256 colors/shades simultaneously. Apple also sells two monitors to go with the video card: a 12-inch monochrome monitor, which can display gray scales, and a 13-inch RGB monitor.

However, you do not have to buy Apple's video card, nor one of its monitors. Several third-party manufacturers, such as E-Machines Inc. and Super-Mac Technology, have announced their own video cards and monitors for the Mac II.

Using the Mac II

Unpacking and setting up the Mac II took about 10 minutes, and I was taking my time. To turn on the machine, I reached to the back (right side) and pushed the power button. The monitor came on, the system booted up with the usual Mac display, and it was ready to go.

You go through this installation only once. From then on, switching on the Mac II is accomplished from the keyboard: You press a key labeled with a triangle (present on both the standard and extended keyboards), and the power's up.

The Macintosh II comes with version 4.1 of System (the operating system) and version 5.5 of Finder (the user interface). These versions have no major changes from previous versions, but there are a number of minor ones, particularly in Finder. The most significant is that the Control Panel desk accessory (DA) now has subpanels for each major hardware device (General, Keyboard, Monitor, Mouse, Sound, and Startup Device). Third-party hardware manufacturers can define subpanels for their products, and by dropping these files into the System Folder, you automatically install and select them as part of the Control Panel.

Using the Mac II is pretty much like using a regular Macintosh, but with two

continued

Bruce F. Webster (P.O. Box 1910, Orem, UT 84057) teaches at Brigham Young University.

Macintosh II

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

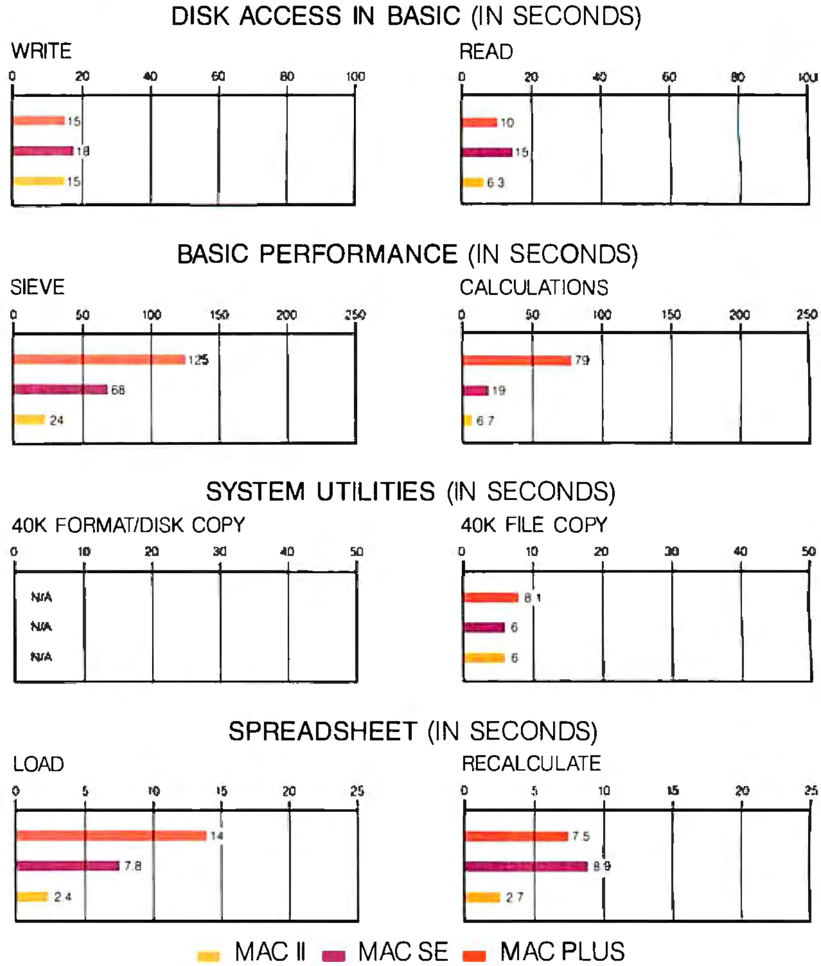
Size
18⅔ by 14⅓ by 5½ inches;
24 to 26 pounds

Components
Processors: Motorola 68020 CPU and Motorola 68881 math coprocessor running at 16 MHz
Memory: 1 megabyte of RAM, expandable on the motherboard to 8 megabytes; 256K bytes of ROM
Mass storage: Both models come with one 800K-byte 3½-inch floppy disk drive; one model comes with a 40-megabyte hard disk drive
Expansion: Six NuBus slots
I/O interfaces: Two DIN-8 serial connectors; two Apple Desktop Bus (ADB) ports; one SCSI port
Mouse: Mechanical tracking; optical shaft encoding at 90 pulses per inch; ADB connector
Sound: Apple custom digital sound chip, including 4-voice wave-table synthesis

Options:
Processors: Motorola 68851 paged memory management unit (PMMU) chip: $499
Memory: 1-megabyte RAM expansion (256K-byte chips): $349
Display: Apple video card, supports 640 by 480 display with 4 bits per pixel: $499; Apple video card expansion, expands video memory to 8 bits per pixel: $149; Apple 12-inch monochrome monitor: $399; Apple 13-inch RGB monitor: $999
Keyboard: Apple Keyboard (81 keys, including numeric keypad and cursor keys): $129; Apple Extended Keyboard (105 keys, including 15 function keys, numeric keypad, cursor keys): $229
Mass storage: Additional 800K-byte floppy disk drive: $299; 20-megabyte hard disk drive: $999; 40-megabyte hard disk drive: $1599; 80-megabyte hard disk drive: $2699

Documentation
263-page user's manual

Price
With 1 megabyte of RAM and one 800K-byte 3½-inch floppy disk drive: $3769
With 1 megabyte of RAM, one 800K-byte 3½-inch floppy disk drive, and a 40-megabyte hard disk drive: $5369



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The Mac II and Mac SE used System 4.1, Finder 5.5, and Microsoft BASIC 2.1(b) for the System benchmarks. The Mac Plus used System 3.0, Finder 5.0, and Microsoft BASIC 1.0 for the System benchmarks. Multiplan 1.02 was used on the Mac Plus and Mac II; Multiplan 1.1 was used on the Mac SE.

important differences: Everything happens much faster, and the screen is larger.

With the Mac II, the agonizing wait of the orignal Macintosh is gone: Applications and data files load very quickly, and application operations take less time. Windows jump open at amazing speeds, and file copies from the floppy disk to the internal drive were completed sooner than I expected. You can have several DAs operating simultaneously with little or no degradation of performance.

A number of the applications that I tried recognize the larger screen and automatically size their windows to match. For example, the editor window on Consulair's Edit version 2.1 fills most of the screen, allowing you to look at 123-column-wide code listings. So does Lightspeed C version 2.01, with its built-in editor. Microsoft Word 3.0 and SuperPaint also size their windows this way, giving you the ability to easily manipulate information on large documents.

Interestingly, some old programs also detect and use the extra screen space, among them Multiplan 1.02 and MacDraw 1.9 (although MacDraw's Lines menu behaves rather strangely, blanking the menu items as you use it). Unfortunately, some applications have their window dimensions hard-coded in, so that the window can't expand to make use of the extra space. This limitation is easier to tolerate if you can drag the window to another part of the screen (such as with MacWrite 4.5), but some applications don't allow you to move the small window at all (e.g., MacPaint 1.5 and Red Ryder 9.4).

The vast screen size (compared to the 9-inch monitor on the original Macintosh) also affects how you work with the Mac II. For example, the Alarm Clock DA is virtually useless on a small screen: When you summon it up, it becomes the foreground window and disables the menus in the application you're working with. Clicking on the application's window to reactivate the menus doesn't help—this hides the Alarm Clock display. But with a large screen, you summon up the Alarm Clock, drag it to an unused portion of the screen, and click back in the application window to resume work. Then you can edit, write code, or telecommunicate with an on-line service while having a running time display.

You can use a compiler to produce an application you're working on, the MockWrite DA to take notes, and the Alarm Clock DA to let you know when it's getting really late, and you don't have to shuffle through the various windows to find what you need. It's all there on the roomy screen. You find yourself arranging desk-accessory windows so that, as you use your favorite application, you can summon up additional information or handle some minor task at the click of a mouse.

To shut off the Mac II, you select the `Shut Down` command from the special menu on the desktop. This takes care of any operating system housekeeping, parks the heads on the hard disk, and actually turns the power off for you.

Color on the Mac II

One of the major features of the Mac II is its support of color. As mentioned earlier, the fully expanded Macintosh II video card supports a display with 256 simultaneous colors from a palette of 16 million (8 bits of information each for red, green, and blue). Dithering techniques can dramatically increase the number of apparent colors on the screen. This color capability is supported by Color QuickDraw, which is an extension—not a replacement—for the original QuickDraw that provides the Mac with its powerful graphics primitives. Apple also sells an RGB monitor, manufactured by Sony, which yields a clear, crisp picture.

Unfortunately, the system I reviewed came with the unexpanded video card (only 4 bits per pixel) and a monochrome monitor; Apple has a large backlog on the color monitor orders and was unable to supply one in time for this review. Selecting all 4 bits (16 shades of gray) from the control panel had a noticeable effect: The Apple logo on the menu bar developed shaded gray strips (corresponding to the color strips on the real logo).

All was not lost, though. Sony sent me one of its multiscan RGB monitors (Sony CPD-1302), along with the necessary video cable (made by Cables-To-Go). I set the switches on the back of the Sony to "analog RGB," plugged it into the Mac II, and powered up. Everything was still in black-and-white and gray, but I didn't panic; instead, I brought up the Control Panel, selected the Monitor display, and clicked on the Color button. The Mac II redrew the desktop display, and the Apple logo was in color.

That was the good news. The bad news was that I had very little software to show off the Mac II's colors. So, I figured I'd write my own program: More bad news. First, a good many of the compilers I had did not work on the Mac II, or produced code that did not work well (see the section on "Problems," on page 200). Worse yet, none of them had the interfaces and libraries needed to access the Color Manager and Color QuickDraw.

I remembered that the Mac II supported some fixed color routines in the original QuickDraw. These routines let you set the foreground and background colors out of a palette of eight colors. Using a beta version of a Pascal compiler, I whipped up a quick program to draw circles of different colors. It worked fine, and the colors did show up as expected.

Even as I write this, vendors are rushing to fill the need for color displays and support for the Mac II's Color QuickDraw. For example, Manx Software Systems has introduced version 3.4 of its Aztec C compiler; it supports the new Mac II interfaces and generates 68020 code. Think Technologies has circulated both the necessary header files and an application that patches its present C compiler (version 2.01).

Nor have users been stymied by the lack of Apple color monitors. Most online services now have information on how to build adapter cables to connect either the Sony or the NEC JC-1401P3A MultiSync color monitors to a Mac II.

Multiple Monitors

Even more interesting than the Mac II's support of color is its capability to have multiple monitors sharing the desktop display simultaneously. Each monitor requires a video card, which obviously limits you to six monitors (the number of slots in the Mac II). I was able to acquire a spare video card long enough to test out this capability using the Sony color monitor and the Apple monochrome monitor.

Initially, the extra monitor would display only a gray pattern at boot-up. Under the monitor section of the Control Panel, an area of dead space in the display showed something new: two gray boxes representing the two screens hooked to the Mac II. I could drag either one of the boxes to the position I wanted the extended desktop to map across the two screens: left, right, top, bottom, or even diagonally. You select which screen you want to be the master screen by dragging a tiny representation of the menu bar to the desired box.

Upon rebooting, the results are fascinating. The mouse pointer is constrained to the layout that has been set up in the Control Panel. Well-written applications let you drag windows to the extra screen. Microsoft Word 3.0 and MacDraw allow this, although you can't "grow" a window larger than the screen it occupies. The Lightspeed C editor window can actually be grown to fill both screens, although I can't imagine anyone writing code that needs that large a window. I even dragged a color window to straddle the color and monochrome monitors, and I watched the patterns change by color on one screen, and in shades of gray on the other.

continued

A logical structure called a gDevice quietly handles the updating and drawing of each screen as a window crosses the boundary of a monitor. Although you can access gDevice if necessary, for the most part you don't need to deal with it. For the programmer, if your application uses the `screenBits.bounds` global variable to set the boundaries of its window, it should work flawlessly in this type of environment without any additional code. For the typical user, the important thing to know is that the Mac II comes out of the box with this type of video support built-in.

Performance

I ran BYTE's standard C benchmarks on both the Mac II and the Mac Plus. All six tests were first compiled on the Mac Plus using Lightspeed C version 2.01. The resulting object code was run on both the Mac Plus and the Mac II. The tests were then recompiled and rerun on the Mac II, using Consulair's 68020/68881 Mac C compiler version 5.04. The results are in table 1.

First, let's look at the Lightspeed C versions. Ignoring the two floating-point benchmarks (Float and Savage), there's an average performance increase of 4.25—that is, the same code ran 4.25 times faster on the Mac II than on the Mac Plus. This is roughly what you'd expect.

Next, let's look at all three sets of floating-point benchmarks (Float and Savage). These dramatically show the difference between using SANE (standard Apple numeric environment, Apple's floating-point package on the Mac) on the Mac Plus, using the 68881 via SANE on the Mac II, and using the 68881 on the Mac II directly. Moving from Mac Plus/SANE to Mac II/SANE yields a performance increase of 8.5 for both Float and Savage. Moving from Mac II/SANE to Mac II/68881 yields a performance increase of 5.5 for Float and a whopping 41.9 for Savage. The overall boost in speed going from Mac Plus/SANE to Mac II/68881: 48.3 for Float and 353.8 for Savage.

Finally, compare the times of the non-floating-point benchmarks for Lightspeed C and Mac C on the Mac II. Despite the fact that Mac C is generating 68020-specific code, the Lightspeed C versions are faster for every benchmark. The biggest difference is in the Dhrystone, where Lightspeed C is 20 percent faster than Mac C. On the other hand, Mac C's direct access of the 68881 chip can make a tremendous difference in floating-point operations.

For more performance information on the entire Macintosh product line, see table 2, which contains benchmark times measured by the BYTE staff.

Table 1: *Benchmark results for the Macintosh Plus and Macintosh II. "LSC" refers to Lightspeed C version 2.01; "Mac C" refers to Mac C version 5.04 for the 68020/68881. The benchmarks are described in more detail in "A Closer Look" by Richard Grehan, in the September BYTE.*

Benchmark	Mac Plus/LSC	Mac II/LSC	Mac II/Mac C
Dhrystone	724	2631	2106
Fib	247.3	58.9	83.8
Float	125.7	14.4	2.6
Savage	1910.6	226.2	5.4
Sieve	56.2	11.9	16.7
Sort	89.0	19.6	23.2

Table 2: *Benchmark timings for the Macintosh product line, using the C language benchmarks described in "A Closer Look." All times are in seconds, with the exception of the Dhrystone results, which are in Dhrystones per second. Consulair's Mac C 68020 compiler version 5.04 was used with the 68020 processors, and Mac C version 5.04, which produces 68000 code, was used for the 68000 processors. "SE/HC" is a Mac SE using General Computer's HyperCharger 68020 accelerator board, and "SE/LP" is a Mac SE using Levco's SE Prodigy 68020 accelerator board.*

Benchmark	Mac II	Mac SE/HC	Mac SE/LP	Mac SE	Mac Plus
Dhrystone	2106	2176	2380	574	480
Fib	83.7	71.6	71.5	263.5	327.22
Float	2.6	4.0	2.6	230.2	228.3
Savage	5.4	8.9	5.2	1921	2049.2
Sieve	16.8	14.9	14.8	64.6	77.6
Sort	23.2	20.5	20.4	103.8	124.6

Problems

Given all the changes between the Macintosh II and its predecessors, problems were bound to happen. The original Mac design was a closed, fixed box, and the temptation among developers was to make assumptions about the hardware and software, despite Apple's warnings to the contrary. Apple itself faced challenges in moving toward the open architecture of the Mac II.

The single biggest hardware problem is the CPU bottleneck. Other than the standard 68881 math coprocessor, a truly intelligent move on Apple's part, there is very little distributed processing. Instead, the 68020 must draw each and every pixel on the graphics screen. A graphics coprocessor that intercepts many (or most) of the QuickDraw calls could enhance performance tremendously, as could direct-memory-access circuitry for the disk drives.

The biggest software problem is incompatibility. There are several reasons for this, some of which are Apple's fault, some of which are the developers' fault, and some of which are just inevitable.

Apple's biggest problems center around bugs in the ROM and the operating system (currently, version 4.1). I've talked with a number of developers, some with large third-party firms, who have been frustrated by the impact that Apple's bugs have had on their products. Some manufacturers have had to make quick patches to their programs, because it's necessary to work around some of Apple's bugs.

Many software incompatibilities, however, are due to poor planning on the part of the developers. Apple has been warning developers for months not to depend on absolute memory locations (other than specifically defined system globals), not to presume anything about screen dimensions (which results in those stuck windows I described earlier), and especially not to use programming techniques incompatible with the 68020.

One major source of problems has to do with the 68020's instruction cache. In this cache, the 68020 keeps the last 64 instructions that it has executed, along with the address (in memory) of each. When the 68020 is about to fetch its next instruction, it checks first to see if that instruction is already in the cache. If so, it loads the instruction from the cache, avoiding a fetch from memory and thus speeding up execution. Small chunks of code, such as tight loops, can fit entirely inside the cache, enhancing performance dramatically.

Why does this cause problems? Because some programs, particularly those with copy protection, use self-modifying code. If the original, unmodified instructions are still in the cache, then they are executed instead of the modified ones. In another form of the same problem, usually involving system I/O calls, a set of instructions is created in some unused portion of memory (such as on the stack) and then executed. If two such calls are made close together and are created at the same locations, the cache may still contain the instructions from the first call and may use those instead of the ones just created.

Unfortunately, the Mac II has no provisions for disabling the 68020 cache. This is a real deficiency, since the 68020 does have a cache-disabled mode, and most of the 68020 accelerator boards for the Mac Plus and Mac SE allow you to disable the cache via a desk accessory. Given the flexible nature of the System 4.1 Control Panel, I'm surprised that Apple did not implement such an option. However, at least one public domain application (cachectrl) and one FKEY (Disable Cache) have surfaced to let you do this.

Finally, here's a hard one for me to make a call on: Virtually every paint-style application mashed the screen display when I used more than 1 bit for the pixel depth, either in gray-scale or in color. Although the program still functions, several patches of gray or color garble the upper portion of the screen. MacPaint 1.5, SuperPaint 1.0, and FullPaint 1.0 (which had been hacked to operate on a Mac SE) all did this. I corrected the problem by setting the colors to 2 in the control panel, but it's a nuisance swapping between modes.

Because of mistakes by both Apple and the developers, about 10 percent to 20 percent of the Macintosh programs on the market, at the time of this writing, won't work on the Mac II. That percentage should shrink significantly by the time this review sees print. In fact, Apple itself is already trying to correct problems with its own programs by offering an update plan for owners of MacTerminal, MacDraw, MacProject, and MacWrite.

The Open System

The Macintosh II is probably the best and most important product that Apple has released since the original Apple II. It represents the end of the closed-box legacy of the original Mac and a return to the open architecture that continues to sell the Apple II, despite its age and obsolescence.

However, much like the current 80386 systems, the Mac II is a tad underbaked. Little software exists to take advantage of the Mac II's power, and current software suffers from compatibility problems. While Apple did a lot of things right, there was still some shortsightedness at work.

Should you buy a Macintosh II? If you've got the money and the need, then, yes, the Mac II is worth buying. It has some of the drawbacks of any new architecture, but it has the advantages as well: speed, power, and expandability. Most important, it has tremendous third-party support, and those third-party manufacturers will transform the Mac II into a far better machine than it is now.

Three years ago, I described the original Macintosh as "a gem—rough, slightly flawed, but a gem nonetheless." Those same words apply just as well to the Macintosh II, but with one important difference: Here's a gem that you can cut and polish yourself. ■

The GRiDLite Laptop

John Unger

Grid's portable: A mixed bag of advanced features and mundane hardware

The GRiDLite Model 1032 laptop differs from GRiD's earlier portables, which had rugged magnesium cases, custom ROM modules, and high price tags. The GRiDLite 1032 has a lower price ($1750), a high-impact plastic case, and up to a megabyte of ROM.

This machine's hardware represents a "bad news/good news" story. The 80C86 CMOS CPU runs at 4.77 megahertz, and the standard machine has only one 3½-inch floppy disk drive, 128K bytes of RAM (the 1032 with 640K bytes of RAM is $600 extra), and a 3- to 4-hour battery lifetime. There are no slots for accessory boards other than an optional modem.

On the good news side, the supertwist LCD display is bright and easy to read, and you can put a megabyte of ROM in this machine. The rest of the system is comparable to other laptops and includes a parallel and a serial port, a port for an IBM CGA-compatible color monitor, a connector for an external 3½-inch disk drive, and provision for an internal 1200- or 2400-bit-per-second modem.

A Closer Look

The GRiDLite 1032 is about the same size as other laptops, and its single disk drive and small battery keep its weight down to 9 pounds. Two sliding latches on the top front edge of the case unlock and raise the screen. There is sufficient friction in the screen's hinges to let you set it at any angle between about 60 and 120 degrees.

The laptop comes with an internal 9.6-volt, 1-ampere-hour nickel-cadmium battery and an external combination power supply and battery charger. After only 3 to 4 hours of use, the red warning light on the keyboard begins to glow. If you need longer battery life, you can either purchase another internal battery (changing the battery is a trivial task) or buy the optional external nickel-cadmium battery pack, which lasts about 10 to 12 hours.

The GRiDLite's one 720K-byte, 3½-inch floppy disk drive is located at the rear of the right side of the computer, which means that you need some clearance on that side to get the disks in and out. A small green LED at the top of the keyboard glows when the disk drive is being accessed.

A second external 3½-inch disk drive is available as an option. The disk drive is powered through the drive cable that plugs into a dedicated DB-25 connector on the rear of the computer. This allows the drive to be quite small (4¼ inches wide, 1½ inches high, and 6½ inches deep). The cable connector adds about 2½ inches to the depth of the drive.

The system's eight ROM sockets can accept either 64K-byte or 128K-byte ROM or EPROM ICs. Four of the sockets hold either 28-pin or 32-pin ROM chips; the other four sockets hold 28-pin GRiDLite ROM cartridges. These are much easier to install than standard ROM packages because the pins don't bend as easily.

My review system came with six ROM sockets filled. Three sockets contained GRiD's Integrid DOS shell software. A fourth had MS-DOS 3.2's COMMAND.COM, hidden system files, and a few DOS utilities. Crosstalk was loaded on two GRiDLite ROM cartridges. The remaining DOS utilities and the PC-to-GRiD communications program are on floppy disks. GRiD offers a variety of software on ROM chips, at the list price of the software plus $50. You get all the manuals and the original disks in addition to the programs in ROM.

You can buy the GRiDLite with either 128K bytes, or, for an additional cost of $600, 640K bytes of RAM. You can buy either 512K bytes or 1024K bytes of additional RAM for the 128K-byte GRiDLite. This RAM is compatible with the Lotus/Intel/Microsoft Expanded Memory Specification (EMS) and is installed as a piggyback module under the floppy disk drive. GRiD also includes a RAM disk program. Adding memory chips to the GRiDLite is not a user option; it must

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The Wang LapTop

Alex Lane

Wang's portable: A bridge between Wang and PC computing environments

To the designers of the Wang LapTop computer ($3530), IBM PC compatibility was a secondary consideration. Wang's LapTop computer is chiefly a Wang-compatible remote terminal capable of running PC software. This 14¼-pound machine features an 8-megahertz, 16-bit NEC V30 CPU, 512K bytes of RAM, and a 10-megabyte hard disk drive. Built into this laptop are a Wang communications interface (you need the optional Wang Systems Networking software), a thermal-transfer printer, and a rechargeable nickel-cadmium battery that supplies power for up to 4 hours.

With the LapTop computer, you get a power supply, a roll-paper attachment, a roll of paper, a set of system disks, a carrying case, documentation, and a pair of function-key overlays. The case, however, is large enough to hold only the computer and a few disks. The standard software includes MS-DOS 3.2, GWBASIC 3.2, and Wang enhancements such as diagnostics, system utilities, and Wang's Industry Standard PC-emulation mode.

My review machine had the following options: an external numeric keypad, one 3½-inch and one 5¼-inch external floppy disk drive, a 512K-byte memory expansion card, and a 2400-bit-per-second internal modem. The total cost for the laptop and options was $5998.

A Hefty Package

When closed, Wang's LapTop looks more like a small portable typewriter than a computer. The rear half of the machine contains a thermal dot-matrix printer, complete with platen knob, paper slot, and release lever.

The LapTop weighs 14¼ pounds and measures 14 inches wide, 12 inches deep, and 4 inches high. It is one of the larger and heavier laptops, and it is definitely intended for two-handed use, even down to the LCD screen's latches on both sides of the machine.

On the computer's left side is the RS-232C serial port and a pair of jacks for the telephone line and handset. On the right side is the power switch, a jack for the numeric keypad, a printer switch, and the SCSI port. The rear panel contains only an adapter plug for the 21-volt DC power supply. The parallel port is conspicuously absent. (Wang makes only serial printers.)

High Performance

Unlike the Intel 8088, with 16-bit architecture and only eight address lines, the LapTop's 8-MHz NEC V30 is a true 16-bit microprocessor. The performance difference shows in the LapTop's Sieve and Calculations benchmark times. Wang's LapTop is 20 percent faster than the 7.16-MHz Toshiba T1100 Plus, and 60 percent faster than the 4.77-MHz IBM PC.

The LapTop comes with 512K bytes of RAM, and you can install another 512K-byte memory module in a dedicated slot in the back of the machine. Unlike PC clones that are limited to 640K bytes of addressing, the Wang LapTop can use the entire megabyte when running Wang software. In Wang's Industry Standard PC-compatible mode, the DOS 640K-byte address space can be supplemented by a 400K-byte RAM disk.

Wang offers two internal Hayes-compatible modems (1200- and 2400-bps) that share the serial interface with the RS-232C serial port; when the modem is on, the serial port is disabled. You can turn on the modem and control its configuration via a Wang utility program and a communications menu.

The LapTop's hard disk drive is fast. Its BASIC Disk Write and Disk Read times come in at 18.3 seconds and 14.3 seconds, respectively. The hard disk also tolerates transportation well. After I commuted with the LapTop for a month, the format procedure reported the appearance of only one bad sector out of over 2400. To conserve battery power, you can make the hard disk stop spinning when it hasn't been accessed for a time. (You specify the time in the CONFIG.SYS file.)

Although putting a 10-megabyte hard

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Alex Lane (c/o Reynolds, Smith and Hills, P.O. Box 4850, Jacksonville, FL 32201) is a senior software engineer.

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be performed by GRiD technicians.

The optional 1200-bps internal modem furnished with my computer functioned perfectly. It was completely Hayes-compatible and worked fine with Crosstalk, Qmodem, and ProComm.

Keyboard

Squeezing all the functions of a full-featured, IBM-type keyboard onto the GRiDLite's 71 keys requires some compromise in convenience. GRiD uses a shift-type Function key in combination with other keys to invoke functions, in the same way as IBM's Shift key is used. Some keys can invoke up to four functions if they are used with both the Function and Shift keys. Twelve numbered function keys are arranged in a row at the top of the keyboard. You can access ten of these directly; the remaining two do double duty as the Insert and Delete keys and have to be pressed with the Function key to respond as function keys.

A numeric keypad is superimposed on keys of the main keyboard, and GRiD supplies a utility program to make access to them as easy as possible. However, the layout is not very convenient, and I preferred sticking to the normal number keys along the top of the keyboard.

This keyboard has full-size keys with a good feel, but they give no audible feedback and call for a lighter touch than I am used to. Four editing keys at the right end of the keyboard act as arrow keys and as PageUp, PageDown, Home, and End when used with the Function key. This layout worked well for me.

Display

The supertwist LCD screen is one of the GRiDLite's strong points. It gives superior contrast without power-hungry backlighting and can be viewed from as much as 45 degrees off to the side.

This screen features blue-black characters on a yellow-green background. The characters are well-formed from an 8- by 8-pixel matrix, and the standard text mode is 80 characters by 25 lines. The GRiDLite supports both CGA 320- by 200-pixel and 640- by 200-pixel graphics modes. However, there appear to be only three, or possibly four, distinct shades of blue-gray in CGA mode. You have to adjust the contrast carefully to discriminate between the two darkest shades.

The screen is 8½ inches wide by 6½ inches high, which gives an aspect ratio of 1.3 to 1 (width to height). This value is the same as that of most CRT monitors, which means that graphics figures, such

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GRiDLite Model 1032

Company
GRiD Systems Corp.
47211 Lakeview Blvd.
Fremont, CA 94538
(415) 656-4700

Size
11⅕ by 13⅓ by 2⅘ inches;
9 pounds

Components
Processor: 4.77-MHz 80C86
Memory: 128K bytes of RAM, standard, expandable to 640K bytes on system board; up to 1 megabyte of optional internal EMS RAM; up to 1 megabyte of ROM
Mass storage: One 720K-byte double-sided, double-density 3½-inch floppy disk drive; optional second 3½-inch floppy disk drive
Display: LCD supertwist, 25 lines by 80 columns; 320- by 200-pixel color graphics or 640- by 200-pixel monochrome graphics; screen size: 8½ by 6½ inches
Keyboard: 71 keys, including 12 function keys; special editing key cluster; embedded numeric keypad selectable on ASCII keyboard
I/O interfaces: RS-232C serial port; Centronics-compatible parallel port; external floppy disk drive port for optional 3½-inch disk drive; RGB video port (IBM PC-compatible); standard telephone jack for internal modem
Other: Internal nickel-cadmium rechargeable; approximate lifetime, 3 to 4 hours

Software
MS-DOS 3.2, GWBASIC 3.2; file-transfer and other utilities

Options
640K-byte RAM expansion: $600
External 3½-inch floppy disk drive: $295
External nickel-cadmium battery pack: $175
512K-byte EMS RAM: $295
1024K-byte EMS RAM: $395
Hayes-compatible 1200-bps modem: $395
Hayes-compatible 2400-bps modem: $595

Documentation
46-page *GRiDLite Owners Guide* (includes index); 24-page *Using MS-DOS and the GRiDLite*; 290-page *MS-DOS 3.2 Reference Manual* (includes index); 423-page *GWBASIC User's Guide* (includes index)

Price
Base Model 1032 with 128K bytes of RAM: $1750

Wang LapTop

Company
Wang Laboratories Inc.
One Industrial Ave.
Lowell, MA 01851
(617) 459-5000

Size
14 by 12 by 4 inches; 14¼ pounds

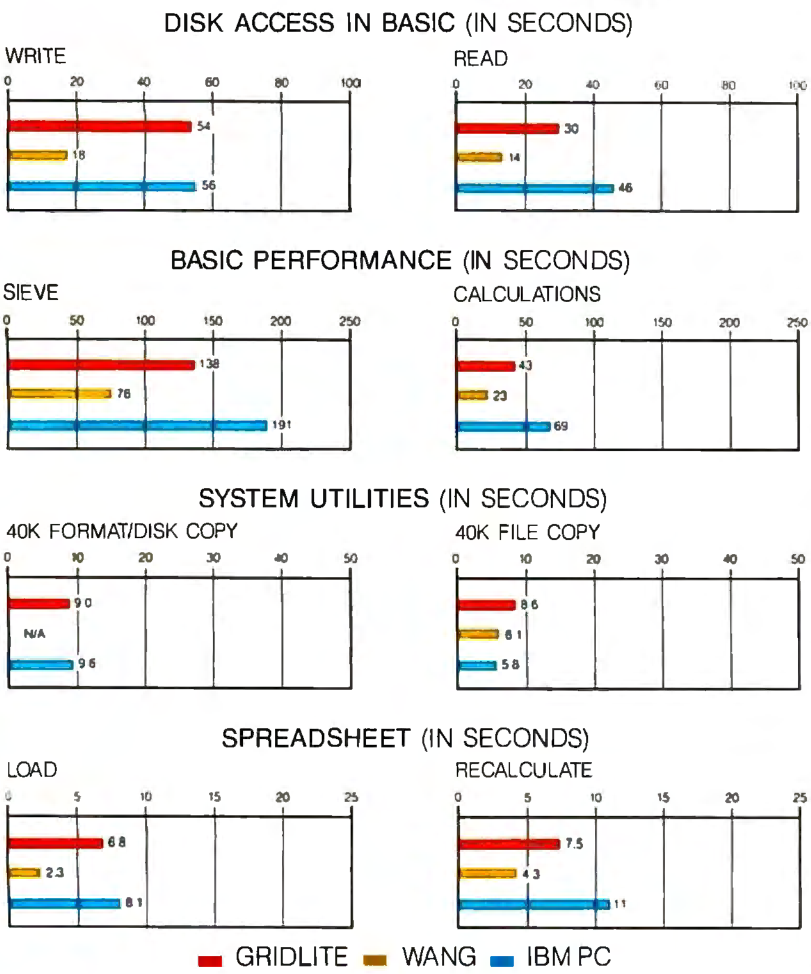
Components
Processor: 8-MHz NEC V30
Memory: 512K bytes of RAM standard, expandable to 1 megabyte
Mass storage: 10-megabyte internal hard disk drive; optional external 3½- and 5¼-inch floppy disk drives
Display: 80-column by 25-row supertwist LCD, emulates IBM CGA in monochrome; screen size: 9 inches by 4 inches
Keyboard: 90 keys, including 16 function keys; optional numeric keypad
I/O interfaces: Optional 2400-bps asynchronous or synchronous/asynchronous modem; RS-232C serial port; SCSI port
Other: Built-in thermal printer; rechargeable nickel-cadmium batteries (12-volt sub-C pack); approximate lifetime (with printer and modem on): 4 hours

Software
Proprietary Wang; MS-DOS 3.2; GWBASIC 3.2

Options
3½-inch 720K-byte external floppy disk drive: $518
5¼-inch 360K-byte external floppy disk drive: $365
Numeric keypad: $95
512K-byte RAM expansion: $695
1200-bps modem: $425
2400-bps modem: $795
Wang Systems Networking software: $400
Wang Integrated Word Processing: $385
Wang Asynchronous Communications software: $100
Car lighter attachment: $25

Documentation
Fundamentals Guide; Troubleshooting Guide; Modem User's Guide; Asynch User's Guide; DOS Command Processor Guide; Printer Software Administration Guide; Installation Instructions; BASIC Guide; PC User's Guide

Price
System unit: $3530 (includes system software with GWBASIC, MS-DOS 3.2, carrying case, roll-paper attachment, roll of paper, power supply, battery, and function-key overlays)



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, formatted 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. Tests on the GRiDLite were done using MS-DOS 3.2, GWBASIC 3.2, and Multiplan 1.06. The GRiDLite had one double-sided, double-density 720K-byte internal floppy disk drive, one external 720K-byte floppy disk drive, and 640K bytes of RAM. Tests on the Wang LapTop were done using Wang GWBASIC 3.2, Wang's Industry Standard DOS, and Multiplan 1.06. The LapTop tested had the 10-megabyte internal hard disk drive and 360K-byte and 720K-byte floppy disk drives. Test times for both of the Wang's floppy disk drives were identical, so the charts indicate only one figure for both drives.

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disk drive inside the LapTop is laudable, not having a built-in floppy disk drive is annoying. If you travel and must carry software and data, you'll soon tire of lugging a disk drive about in a separate case.

The LapTop's external disk drives communicate via the SCSI port, which lets you connect up to six other disk drives or peripheral devices. The disadvantage of SCSI is a lack of compatibility with some PC software. The Norton Utilities is a notable example: The software expects to deal with a standard PC disk controller.

The LapTop's 3½-inch disk drive can run on rechargeable batteries, or you can connect it and the computer to the power supply via a T connection. The 5¼-inch disk drive uses only AC power and comes with a connecting cable to attach it either to the system unit or to the back of the 3½-inch disk drive. The 3½-inch drive uses 720K-byte disks, so you can't do a DOS `DISKCOPY` to or from the 5¼-inch disk drive.

The performance of both external disk drives compares favorably to the drives installed in other laptops. The Read (29.66 seconds) and Write (31 seconds) benchmark results of both of the LapTop's external disk drives are as fast as the fastest disk drive (Toshiba T1100 Plus—Read 30 seconds, Write 31 seconds) of the laptops reviewed in "Four Portable Computers" by John Unger in the February BYTE.

Keys and Pixels

The LapTop's keyboard, like other Wang keyboards, resembles a pre-PC typewriter. Sixteen function keys are arranged horizontally above the full-size QWERTY keyboard. These keys, along with the shift key, give you 32 functions. The keyboard is comfortable and easy to adapt to, with one major exception: The Control key is small and is located in a cramped position to the left of the space bar. DOS programs like XyWrite, which use control-key sequences, are difficult to use with this keyboard. Also, the gray plus and gray minus keys are found only on the separate numeric keypad, making it difficult or impractical to use packages like Framework without the keypad.

If you input a lot of numeric data, I strongly suggest that you obtain the numeric keypad. The keypad's functions are toggled by the F16 key, which doubles as the Num Lock key. When not in Num Lock mode, the keypad's functions are the same as the IBM PC's numeric keypad.

The LapTop's 9- by 4-inch screen is an 80-column by 25-line supertwist LCD

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as pie charts, will look the same when displayed on the GRiDLite's screen.

Specialized Software

MS-DOS treats the files residing in the special ROM packages as though they are on the A: drive. One peculiarity of this system is that you can have two identical files with the same name in a directory—one in ROM and the other on the disk. If you execute a program that exists both in ROM and on the disk, the system will run the version from the disk. The CHKDSK command adds the amount of ROM to the amount of disk space on drive A:.

The MS-DOS 3.2 operating system provided with the GRiDLite includes specialized utility programs and unique versions of standard MS-DOS programs, designed specifically for this machine. The MODE command is a good example. With the GRiDLite, you can use this command to turn on power to the modem or the serial port, to switch the COM1: device between the modem and the serial port, or to change the the size of the cursor. GRiD's version of MS-DOS also includes an extremely useful HELP utility program that supplies information about using DOS commands and functions.

ROM-based software can be beneficial on a laptop. For example, in my review computer, the operating system kernel was in ROM; this meant I saved disk space because I never had to format a disk with the /S option to include the MS-DOS system files and COMMAND.COM. In addition, the machine booted much faster from a cold start. If you need them, you can simply have AUTOEXEC.BAT and CONFIG.SYS files on the disk in the A: drive. The convenience of having a communications program like Crosstalk in ROM is twofold: First, it's always there when you want it; and second, it doesn't take up any disk space or RAM until you need it.

The GRiDLite uses Phoenix Corp.'s highly IBM PC-compatible ROM BIOS 2.03. I had no trouble running any of my IBM software on the laptop.

Performance

The GRiDLite's performance is adequate but not outstanding. The main reasons it does better than the IBM PC in the benchmarks are its 80C86 chip, versus the 8088 in the IBM PC, and the improvements in version 3.20 of GWBASIC. The GRiDLite outperforms the Toshiba T1100 Plus when the Toshiba is running in its 4.77-MHz mode, and in disk I/O operations even when the T1100 Plus is running at 7.16 MHz. The figures are impressive. The GRiDLite did the Sieve benchmark in 138 seconds; the Toshiba T1100 Plus at 4.77 MHz took 142 seconds. The GRiDLite did the 40K-byte File Copy benchmark in 8.2 seconds; the T1100 Plus (at high speed) took 11.4 seconds.

Because the GRiDLite lacks an external 5¼-inch disk drive, there are two options for transferring files and programs between a PC and the GRiDLite; both use a null modem cable between the serial ports of the PC and the laptop. The first and most direct method simply uses a communications program, such as PC-Talk or Crosstalk, running on each machine, to upload and download files from one machine to the other. The second method, and the one GRiD recommends, involves using GRiD's PC master/slave software (included with the DOS utilities) to set up one of the computers as a master node and the other as a slave. To the master micro, the slave machine looks like a logical disk drive with a normal letter designation (e.g., E:). You can then issue DOS commands, such as COPY and DIR, from the master machine to examine and transfer files from one machine to the other. Don't expect high-speed transfer rates from either of these methods; 9600 bps from the serial port is tops.

Pros and Cons

The GRiDLite Model 1032 is a curious mixture of advanced, specialized features and mundane hardware. Its 4.77-MHz clock rate clearly compromises its performance, and its short battery life hurts its usefulness as a truly portable laptop computer.

Moreover, the 90-day warranty period for the computer is short compared with the one-year warranties of the IBM, Zenith, and Toshiba laptops. GRiD will sell you an extended warranty for $180 when you buy the machine; an expanded warranty, which includes a loaner while your machine is being fixed, costs $540. The user pays the initial shipping cost, and GRiD pays the return freight.

On the other hand, having a megabyte of applications software at your fingertips in ROM is clearly an advantage for any portable computer, and the GRiDLite's LCD display is one of the best I have used.

However, I would not recommend the machine for someone who is looking for a laptop capable of doing desktop-like computing and who needs higher performance and expansion capability. Compared with the latest versions of the Toshiba T1100 Plus ($2099 with 640K bytes of RAM), the Zenith Z-181 ($2399 with 640K bytes of RAM), and the NEC MultiSpeed ($2195 with 640K bytes of RAM and two drives), the GRiDLite's performance is not up to par; it has fewer features; and it is not as good a value. ■

continued from page 205

that provides a 7-to-1 contrast ratio. The screen resolution is either 320 by 200 pixels or 640 by 200 pixels in CGA mode. A jack in the side of the screen lets you remove the LCD screen and connect an external color monitor. The screen pivots easily to any position to take advantage of available lighting, since supertwist screens generate no light of their own.

Printer

The integral thermal dot-matrix printer works with either thermally sensitive paper or with a ribbon cartridge and normal printer paper. The printer-control switch turns the printer on and off and also adjusts the darkness of the print.

The LapTop's printer is slow (18 characters per second). A 64-character by 55-line page of text took about 6½ minutes to print in both medium and dark print modes. The ribbon cartridge gets used up rather quickly—I'd estimate that about 20 single-spaced pages can be printed from one cartridge.

The printer uses either single sheets or continuous-form paper, but since the printer has no tractor mechanism, continuous-form media drifts a bit. Two dedicated keyboard keys retract or advance the platen to simplify paper loading and unloading. The machine comes with one roll of paper and an attachment that hangs from the back of the computer. The attachment folds up, but it and the paper do not store gracefully.

Software

The unit I reviewed came with seven 5¼-inch disks: four disks (1.3 megabytes) of system files including DOS 3.2 and GWBASIC 3.2, one diagnostics disk, a printer-support disk, and an installation disk. Wang's optional Integrated Word Processing and Asynchronous Communications packages are on two 3½-inch disks.

When you power up, the CONFIG.SYS file boots the machine into Wang mode and asks if you want to change the time and date. Pressing the EXEC key produces Wang's main system menu. You can now go forward or backward through the menus by using the EXEC and CANCEL keys, respectively.

Selecting `DOS Command Processor` from the main system menu spawns an offspring session of DOS 3.2, identified with the prompt `[Wang] C>`. At this prompt, you can run the SYSMODE utility to switch the machine from Wang mode to what Wang calls "Industry Standard" mode (i.e., PC mode). If you don't run SYSMODE first, attempts to load and run most DOS programs will cause the machine to stop working. I ran Framework II, WordStar 3.3, and Turbo Prolog 1.1 with no problems. A list of "tried-and-found-true" DOS programs was included with the computer, and the documentation acknowledges that not all PC-compatible programs will run.

Wang's Integrated Word Processing is functionally the same as that used on the Wang VS and PC systems. The Asynchronous Communications software gives you telephone-line communications at 300 to 2400 bps, and direct connection to minicomputers and mainframes at 9600 bps.

Technical Support

The LapTop comes with an impressive array of documentation: six small three-ring notebooks that cover everything from taking the system out of the packing boxes to the nuances of the system software. On a practical level, the only problem with having so much documentation is knowing where to find what, and what to take with you when you travel.

As a Wang customer, you are assigned a customer number, which you should have handy when you call. You can call the toll-free number and directly punch in the type of support you are calling for if you have Touch-tone service. Once connected, you are assigned a tracking number for future reference should your problem not be resolved immediately.

Despite not having a customer number, I was not denied support. After a mild interrogation (i.e., name, company, machine serial number), I was given a temporary number. Once past the gates, I found Wang's technical-support people friendly and competent.

Form and Function

When you consider it against the backdrop of PC compatibility, the Wang LapTop computer scores in the mediocre range. It lacks appeal to PC users because of its limited DOS compatibility and unusual keyboard, which cause difficulty with some DOS-based software. From a performance standpoint, I am impressed with the speed of both its processor and its disk drives. I transported the LapTop daily to a real office environment to do real work, and had no problems. Also on the plus side are the internal 10-megabyte hard disk drive and the SCSI port. On the minus side, however, I missed having a built-in parallel port and an internal 3½-inch floppy disk drive.

If your office uses Wang equipment and is considering buying laptops, you should definitely give this machine a careful once-over. If what bothered me doesn't bother you, this LapTop may be just the ticket. ■

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The Definicon DSI-780

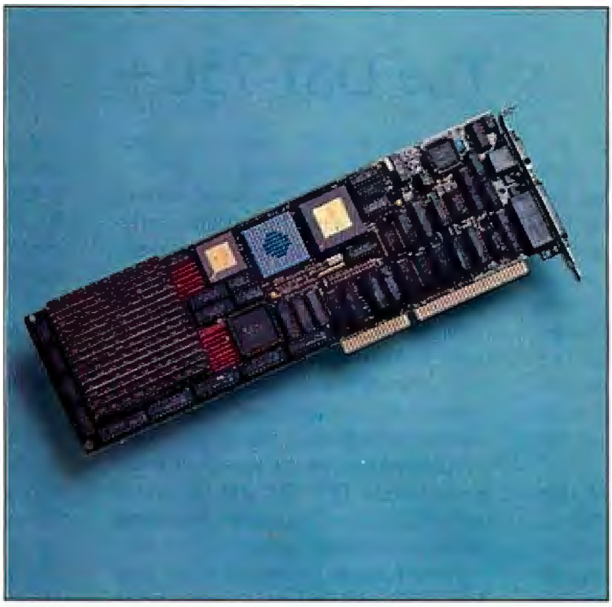
Dave Thomas

A 68020-based XT/AT coprocessor for scientific and engineering applications

Are you frustrated sharing your VAX with 10 other scientists? Do you wish you could run your finite-element analysis in your engineering office, rather than at that expensive service bureau? Do you need a development machine for both Intel and Motorola CPUs? Then the DSI-780 may be the PC coprocessor you need.

The DSI-780 from Definicon Systems runs in the IBM XT, AT, and true compatibles. The board uses the Motorola MC68020 CPU and the 68881 floating-point coprocessor. Multitasking software provided by Definicon allows both an AT-based application and a 780-based application to execute concurrently.

For most 68000 applications, the Definicon board is more than adequate. However, it does not provide the full Unix environment that some developers require.



any page in the 4-megabyte address space of the 780. This architecture facilitates the development of cooperative multiprocessing applications.

I reviewed the DSI-780 board installed in a Packard Bell AT-compatible computer. The Packard Bell was running at 8 MHz with one wait state, and I used MS-DOS 3.1 as the operating system. The machine had an 80287 FPU (also running at 8 MHz), a 1.2-megabyte floppy disk drive, and no hard disk drive. I ran all test programs from a 4-megabyte RAM disk (unless stated otherwise), using two 2-megabyte JRAM cards from Tall Tree Systems, and their supporting software. I had no difficulty installing the board using the instructions provided.

The DSI resident MS-DOS interface lets the board communicate with the operating system using either polled or interrupt mode. (I used interrupt mode for my tests.)

On the Board

The DSI-780's MC68020 CPU and the MC68881 floating-point unit (FPU) run at 16.67 megahertz with no wait states (20- and 25-MHz models are also available). Definicon offers boards in various configurations ranging from $1000 for the DSI-020 (12.5 MHz with 1 megabyte of RAM) to $12,000 for the 25-MHz, 16-megabyte RAM model. (The version of the board that I reviewed had 4 megabytes of 120-nanosecond RAM). The board has an expansion socket for a promised Motorola memory-management-unit chip. Additionally, the DSI-780 is equipped with a 2681 dual universal asynchronous receiver/transmitter (DUART), which drives two RS-232C ports, accessible via DB-9 and DB-25 connectors at the rear of the board.

Software for the board includes both system software and compilers. System software consists of a hardware diagnostic, a minimal assembler, two loaders, and source-level debugger. Definicon offers C, FORTRAN, and Pascal compilers, as well as a BASIC interpreter/compiler and two assemblers (all at additional cost—see page 212 for details).

The Definicon board's communication area resides at address D000:0000 of the IBM AT and at address E000:0000 of the IBM XT. This area is a 64K-byte segment through which the board and DOS talk to one another using three special ports: the control port (at address 2A0 hexadecimal), the page-select port (2B0), and the secondary page-select port (2B8). The secondary page-select port is used on the DSI-780 boards with more than 4 megabytes of RAM. Software running on the XT/AT uses these ports to map the 64K-byte memory window onto any page in the 4-megabyte address space of the 780.

Software

The DSI-780 I reviewed came with Definicon system software and Silicon Valley Software's (SVS) BASIC-Plus interpreter and C, Pascal, and FORTRAN compilers (all were version 2.6). Each compiler package consists of three disks containing the Definicon system software, SVS utilities, and the associated SVS compiler. The system disk contains several programs to test that the DSI-780 board's components are functioning properly, as well as a monitor/debugger

continued

Dave Thomas (School of Computer Science, Carleton University, Ottawa, Ontario, Canada K1S 5B6) is an associate professor of computer science at Carleton University and is a moderator of the BIX Smalltalk conference.

and the loader program. The SVS utilities disk contains the error message files for all three compilers, an object code generator, an assembler, and a linker.

The loader program is responsible for loading files from the host computer into the DSI-780 and for regulating communication and program control between the host and the DSI-780. The loader manages the communications memory area and ports and performs the following functions: It resets and initializes the DSI board; determines the presence and type of DSI board; loads the operating system into the DSI board; resets and transfers control to the DSI board; and services requests from the DSI board until termination.

When the DSI-780 requires service, the loader obtains the service-request information by looking in the interprocessor communication area. From this information, the loader determines the requested service—writing a character to the screen, reading information from the disk, and so on—and begins work on it. When the loader has finished the requested operation, it resets a specific memory location (referred to as the 8086SVC location). While the host CPU is performing its task, the DSI-780 continues with its own operations. However, if the DSI-780 requires another service and the host CPU is not finished, the 780 will wait for the loader to reset the 8086SVC location.

The Definicon loader is actually a DOS shell that allows software executing in the DSI-780 to issue DOS and BIOS calls. I was very impressed by the loader, which cleverly intercepts the calls and forwards them to the AT via a TSR (terminate-and-stay-resident) program. The DSI loader makes performing a compilation and executing the result on the DSI-780 as natural as doing it on the host PC. Since the DSI-780 uses DOS for all file and screen I/O, there is no need for special file formats or terminal I/O. Also, if you install the DSI multitasking loader, you can compile on the DSI-780 and continue working on your PC.

All three compilers performed well. They provide clear, concise error messages for compilation errors, and they let you choose to abort or continue the compilation when an error occurs.

The SVS compilers adhere closely to the standards for their respective languages. FORTRAN-77, for example, insists that you arrange the declarations in a particular order. Pascal accepts few, if any, of the extensions found in some Pascal compilers available for PC-DOS. Such compliance is fine if you're developing new code, but it's very frustrating

continued

The DSI-750+

Last spring, Definicon Systems announced the DSI-750+, which supersedes the DSI-780. Although the 750+ represents a redesign of the 780 board layout, for all intents and purposes it operates identically to the 780. Many of its features are identical to those of the 780: Both are full-size AT-style boards, the installation is the same, you can run the same software (I used the same executable file for benchmarking both boards), and expansion connectors are pin-compatible.

It is interesting to note, however, that although the 750+ operates at 16 MHz, it uses select 12-MHz components. (You can jumper it for 12-MHz operation if you're skittish about running components beyond their rated speeds, but I ran the board at 16 MHz with no problems.)

The 2681 DUART, which is standard on the DSI-780, is optional on the DSI-750+. If you order the board without the DUART in place (this is the configuration I reviewed), then you must operate the board in polled mode, because in interrupt mode the host actually interrupts the 68020 via the DUART. Engineers at Definicon indicated that there was little difference in performance between the interrupt and polled communication protocols, and in fact, when I compared benchmark results of an interrupt-mode DSI-780 with a polled-mode DSI-750+, I found no discernible difference between them.

Table A shows the results of the standard BYTE BASIC benchmarks when executed under SVS BASIC-Plus on the DSI-750+. These figures are very close to those obtained on a DSI-780; the differences are negligible. Next, I ran the C benchmarks that BYTE has been using in the New Generation articles (see table B). Again, the DSI-750+ turns in times so close to those of the DSI-780 that you really can't tell the two apart.

If there's so little difference, why bother producing a new product? Engineers at Definicon told me that the layout and components of the new board make it easier for Definicon to manufacture it. Also, I noticed only one back-of-the-board jumper fix on the 750+, as opposed to several on the back of the 780, so Definicon has probably cleaned up problems in the circuit layout. If you're really concerned about the 12-MHz parts of the 750+, Definicon still manufactures the DSI-780 for people who believe that only 16-MHz CPUs should run at 16 MHz.

Table A: *Standard BASIC BYTE benchmarks for the DSI-750+. The board tested was plugged into an IBM PC AT running at 8 MHz. All times are in seconds.*

	DSI-750+ (16 MHz)	DSI-750+ (12 MHz)	IBM PC AT (8 MHz)
Read	25	25	24
Write	27	27	26
Sieve	6	8	80
Calculations	4	6	27

Table B: *The C benchmarks for the DSI-750+. These benchmark programs are described in "A Closer Look" by Richard Grehan in the September BYTE. All times are in seconds, except for the Dhrystone, which is in iterations per second.*

	DSI-750+ (12 MHz)	DSI-750+ (16 MHz)
Dhrystone	2428	3200
Fibonacci	64.67	48.58
Float	2.98	2.22
Savage	7.45	5.63
Sieve	6.45	4.82
Sort	9.13	6.91

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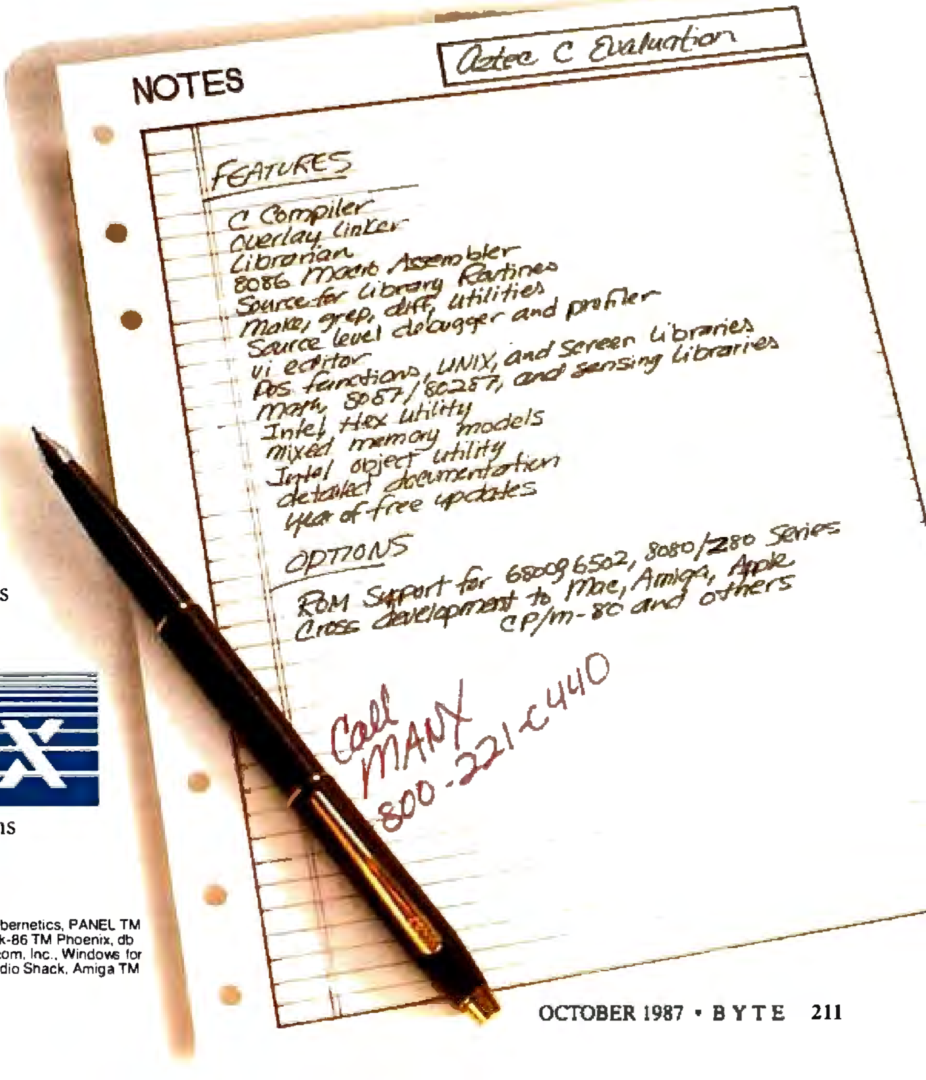

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for people converting existing code. The quality of the compiler-generated code, while adequate, is not as efficient as that generated by the popular GreenHills compilers available on the DSI-32 under Unix. [Editor's note: *See "The DSI-32 Coprocessor Board," a two-part article beginning in the August 1985 BYTE.*]

The SVS assembler is adequate for coding small procedures to be called from C, FORTRAN, or Pascal; otherwise, it's very limited. For example, I took a programming example from another 68000 assembler package, and the SVS assembler gave error messages for the directive `XDEF` (used to declare external definitions) and for an absolute jump instruction, `JMP $2428`. Also, there is no manual provided for the SVS assembler, so it was a little difficult to get started. Definicon recommends the Quelo Assembler (a macro-assemer product also available for the DSI-780) for any serious assembly language work.

Debugging with SDB

One of the major difficulties of developing software for add-in coprocessor boards is debugging a program resident on the board. Definicon provides both a traditional machine-code debugger (similar to the PC-DOS DEBUG program) and a symbolic-level debugger. SDB, the symbolic debugger I reviewed, was a beta copy, but nevertheless I found it very useful. SDB runs on the host processor (8088 for the XT or 80286 for the AT), which means that all the DSI-780's memory is available for the applications program. All the basic debugging commands are provided, including data display, tracing, and breakpoints.

SDB worked with C, Pascal, and FORTRAN programs. One minor annoyance is SDB's case sensitivity to routine names. This is awkward for users who have programs composed of routines written in a mixture of C, Pascal, and FORTRAN.

In summary, while SDB is definitely not as powerful as Microsoft's Code View (the symbolic debugger that Microsoft provides with its C compiler), it is a useful and essential tool for debugging programs executing on the 68020.

Documentation and Support

The documentation was adequate, but it could have been more detailed, better organized, and indexed. The lack of an index in the SVS manuals forces you to search through the entire DSI-780 manual to find a particular feature. Also, the SVS manuals make no reference to the routines contained in PASLIB (the Pascal library), CLIB (the C library), or FTNLIB.P (the FORTRAN library). The SDB manual does not describe the debugger's commands in any logical order.

In contrast to the problems with the documentation, Definicon's technical support is excellent. I used the company's BIX conference (dsi.32bit) frequently, and I received prompt responses to technical questions both electronically and by phone. [Editor's note: *Definicon also operates the Thousand Oaks bulletin board system at (805) 493-1495 for 2400-/1200-bit-per-second calls and (805) 492-5472 for 1200-/300-bps calls. The system is on-line 24 hours a day with software and support for Definicon's products, including the DSI-780.*]

Performance

I used both the BYTE benchmarks and a more traditional scientific test to see if the DSI-780 measured up (see table 1).

It is interesting to observe the figures returned by the Write benchmark. Since all file I/O is handled by the host computer, the speed of the disk write will depend largely on the speed of the host computer. But if you compare the results obtained by the DSI-780 board against those produced by the Packard Bell alone, you'll see that the times from the DSI-780 are faster. This is because the DSI-780 handles some of the job of manipulating the text buffer and leaves the task of writing to the buffer to the host. When the Packard Bell is operating on its own, it has to manage both of these tasks.

Since my major interest in the DSI-780 was its ability to do fast computation, I ran the Whetstone, Dhrystone, and LINPACK tests. I ran LINPACK, an application benchmark, to get a better feel for the speed of the DSI-780. LINPACK is a FORTRAN benchmark developed at the Argonne National Laboratory. It solves a dense set of linear equations, which makes it a useful test of CPU performance in scientific applications.

Although LINPACK produces a number of results, two of them are particularly noteworthy. The first is the Cray Ratio, which is a measure of the CPU power relative to a Cray supercomputer (hence, a Cray scores a 1.0 on this test). The DSI-780 board returned a Cray Ratio of 132.3 on the double-precision LINPACK, while a VAX-11/780 with a floating-point accelerator scored an 89. The second measure is an estimate of the floating-point performance of the machine in millions of floating-point operations (MFLOPS). On this test, the DSI-780 scored a 0.0928, and the VAX-11/780 scored a 0.14 (a Cray scores a 12).

A Cost-Effective Alternative

The benchmarks show that for many applications, the DSI-780 approaches the speed of a VAX-11/780. [Editor's note: *See the text box "The DSI-750+" on page 210 for a speed comparison of the DSI-780 and the DSI-750+.*] You can use this board as a stepping-stone to bring mature mainframe applications into the PC environment. Unfortunately, the SVS

continued

Definicon DSI-780

Type
68020 coprocessor board

Company
Definicon Systems Inc.
1100 Business Center Dr.
Newbury Park, CA 91320
(805) 499-0652

Size
Standard XT/AT full-length expansion card; 13⅓ by 4 by ¾ inches

Features
16.67-MHz 68020 CPU; 16.67-MHz 68881 FPU; expansion socket for MMU; 4 megabytes of on-board memory; uses 8-bit bus (XT) or 16-bit bus (AT); MS-DOS interface software; 68020 DOS-compatible kernel; 68020 memory is memory-mapped into the PC address space

Hardware Required
IBM PC XT, AT, or true compatibles; hard disk drive or RAM disk recommended

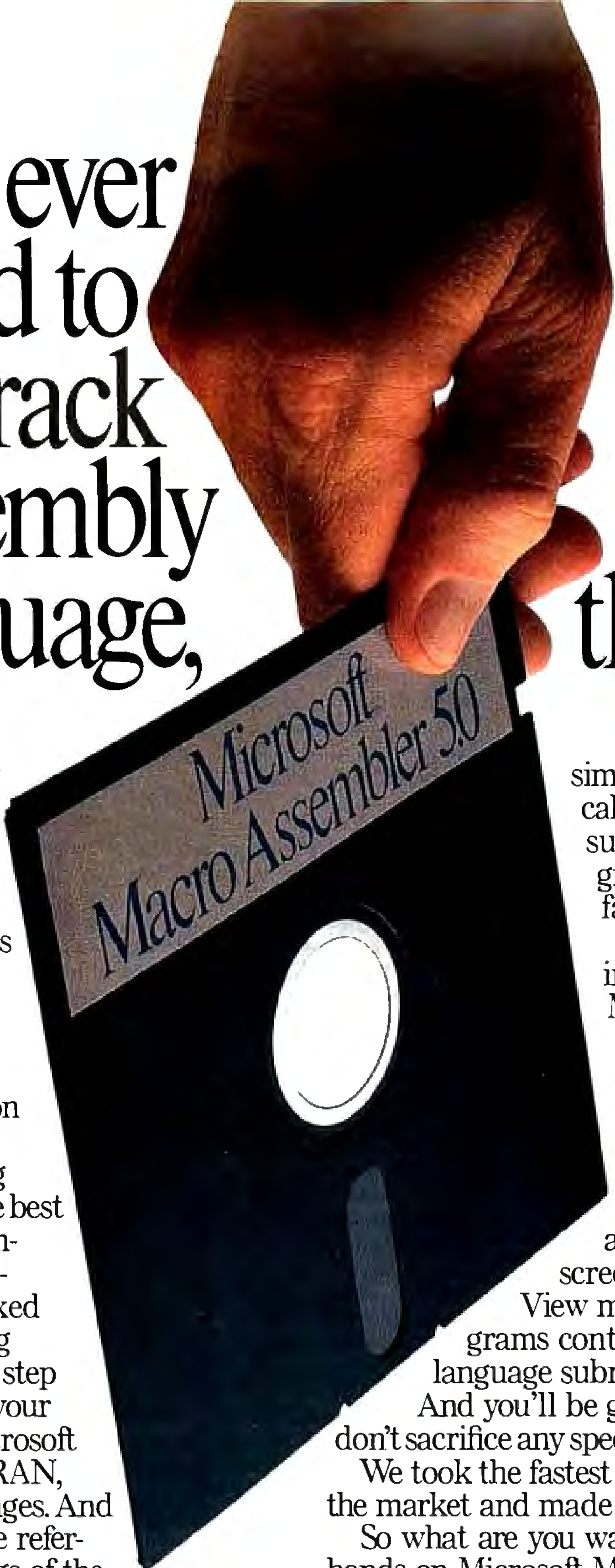
Software Required
MS-DOS 2.0 or higher, or Concurrent PC DOS 4.1

Options
SVS C compiler: $398
SVS Pascal compiler: $448
SVS FORTRAN compiler: $528
SVS BASIC-Plus interpreter: $248
Lattice Logic LTD Pascal compiler: $448
Living Software BASIC-to-C converter: $348
QUELO Macro Assembler and utilities: $198
Library Manager: $48
Public-domain disks (4): $20
Graphics-support disks: $188
SciTech scientific package: $314

Documentation
104-page user/reference manual

Price
DSI-780/4 (with 4 megabytes of RAM and 68020 running at 16.67 MHz): $3295

If you ever wanted to take a crack at assembly language, now's the time.



You probably already know that assembly language subroutines are the smartest way to get the fastest programs.

But if the complexities of working in assembler made you think twice, here's some good news. We've made Microsoft® Macro Assembler Version 5.0 a lot easier to use.

We eased the learning process by giving you the best support around. We completely revised our documentation. The new Mixed Language Programming Guide gives you step by step instructions for linking your assembly code with Microsoft QuickBASIC, C, FORTRAN, Pascal and other languages. And you get a comprehensive reference manual with listings of the instruction set and examples of each instruction. We didn't stop there, though. You also get an on-disk collection of templates and examples.

We've also dramatically simplified the high-level language interface. In just a few simple steps, you can be calling Macro Assembler subroutines from programs written in your favorite language.

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With source code and comments on your screen, Microsoft CodeView makes debugging programs containing assembly language subroutines a snap.

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Circle 178 on Reader Service Card (Dealers: 179)

Table 1: *Benchmarks comparing the 16-MHz DSI-780, running SVS BASIC-Plus on a Packard Bell 8-MHz AT clone, with the Packard Bell alone running GWBASIC. The Read and Write benchmarks are the standard BYTE BASIC benchmark programs to read and write a 64K-byte file. The Sieve benchmark is a BASIC program that closely follows the Sieve benchmark BYTE uses to test C compilers (10 iterations). The Calculations benchmark is the standard BYTE benchmark extended to 100,000 iterations. All times are in seconds.*

	DSI-780	Packard Bell
Read	25.6	26.0
Write	27.0	48.8
Sieve	66.6	587.9
Calculations	36.1	317.7

FORTRAN-77 compiler is not mainframe-quality, so you should expect a week to a month of conversion time if your code is very machine-dependent. Note, too, that the DSI-780 does not provide virtual memory; therefore, you must be sure that your board has the appropriate amount of real memory to accommodate your application.

Some developers, no doubt, will be frustrated by the fact that the DSI-780 does not operate with Unix. However, I found the process of developing software using the Definicon MS-DOS interface to be straightforward.

In addition, unlike Definicon's DSI-32 board, with the DSI-780 you don't have to partition your hard disk into a Unix area and a DOS area and run two different operating systems: The DSI multitasking loader lets you run simultaneous DOS-based editing and 68020 compilation tasks.

What kind of applications are best suited to the DSI-780? Obviously, those that require a linear address space and need lots of CPU power. Typical examples include finite-element analysis, simulation, and font generation. For these and similar applications, the DSI-780 can offload the mainframe and provide a cost-effective solution for PC-based computation.

If Definicon continues to evolve this product (and, particularly, to improve the compilers available), I may consider canceling my order for a Mac II and permanently disconnecting my line to the mainframe. ■

Laser Printer Times Four

Wayne Rash Jr.

The new generation of laser printers is coming within the price range of individuals and small businesses. More manufacturers are offering their own versions of printers based on different laser-printer engines. These new laser printers offer a bewildering array of font styles, memory options, and methods for controlling output. For this comparison review, I looked at four relatively recent entries covering a wide price range: the Hewlett-Packard LaserJet Series II ($2595); the Kyocera F-1010 ($3695); the Okidata Laserline 6 ($1995); and the Epson GQ 3500 ($2199).

The Engines

In most cases, a laser-printer manufacturer buys the actual printing engine from another company, usually one that makes photocopiers. Hewlett-Packard, for example, uses a Canon engine, while the Epson and Okidata printers are both built around engines made by Ricoh. Kyocera builds its own engine.

The major differences between engines relate to the cost of supplies and the life of the machine. Canon was the original maker of low-priced laser-printer engines. The Canon engine uses a cartridge that contains both the toner and the photosensitive drum. This makes it easy to replace supplies when the toner runs out, and it keeps your hands clean.

However, the photosensitive drum, the device that transfers the image to the paper, does not wear out as quickly as the toner runs out. So, when you throw out the expended cartridge from a Canon-engine laser printer, you throw out a perfectly good drum in the process. [Editor's note: *Several companies now advertise that they can recharge your old Canon cartridges for considerably less than the price of a new cartridge. Laser-printer manufacturers, however, do not recommend using recharged cartridges because of possible excessive wear on the photosensitive drum and lack of quality control over the toner supplies.*]

Printers based on the Ricoh and Kyocera engines avoid this problem; they have separate drum and toner cartridges. When the toner runs out, you replace only the toner cartridge. Unfortunately, it's also a lot easier to get toner all over yourself, as I found out more than once.

Of course, the engine is only part of the printer. The printer manufacturer adds electronics that can give an engine different capabilities (e.g., graphics-image size and resolution).

The Tests

To test the printers objectively, I ran a suite of tests that try to simulate actual day-to-day uses of laser printers. The tests include printing a full page of graphics and a full page of combined text and graphics, using every printer emulation available for each laser printer to test for compatibility. Each test was repeated at 75, 150, and 300 dots per inch.

To measure the actual throughput, as compared to the manufacturer's claimed page-per-minute (ppm) speed, I benchmarked these machines in two ways. The first method involved sending a 96K-byte, 30-page text document to the printer with the DOS `COPY` command. In the second method, I set the printers to produce 30 copies and then sent them a single page of text, again using the DOS `COPY` command. Ideally, for a given computer, the times of these two tests should have been the same. In practice, there were time differences.

I timed the printers by pressing the button on the stopwatch at the same time that I pressed the Enter key on the computer. Since the files were on the computer's hard disk, the delay before sending the file to the printer was minimal. I also tested the time it took the printers to run through their power-on, self-test, and warm-up sequences (see the results in the table at right).

I ran these tests on a Tandy 1200 HD with 640K bytes of memory. To test text throughput, I used WordStar version 4, which supports Hewlett-Packard and Apple laser printers. I mixed text and graphics with Ashton-Tate's Framework II version 1.1, and I generated graphics with Lotus's Freelance Plus version 2.

While all printers performed well with WordStar, Framework's word-processing capabilities eluded some printers. In this test, I generated a memo that included bold, underlined, and italic print, along with the normal print and embedded graphics. The graph was a simple

	HP LaserJet Series II	Kyocera F-1010	Okidata Laserline 6	Epson GQ 3500
Company	Hewlett-Packard 3000 Hanover St. Palo Alto, CA 94304 (800) 367-4772 (415) 857-1501	Kyocera Corp. 3165 Adeline St. Berkeley, CA 94073 (800) 367-7437 (415) 848-6680	Okidata 532 Fellowship Rd. Mount Laurel, NJ 08054 (800) 654-3282 (609) 235-2600	Epson America Inc. 2780 Lomita Blvd. Torrance, CA 90505 (213) 539-9140
Warm-up time (in seconds)	26.0	21.5	32.0	33.0
Time to print one page (in seconds)	29.0	22.0	27.8	29.1
Time to print 30 copies (minutes:seconds)	3:58.0	3:17.1	5:05.8	5:09.4
Time to print 96K-byte file (minutes:seconds)	5:49.0	3:13.1	5:05.9	5:07.0
Rated speed	8 ppm	10 ppm	6 ppm	6 ppm
Price	$2595	$3695	$1995 (includes Personality Module)	$2199
Resident fonts	6	40	15	7
Ports	Serial and parallel	Serial and parallel	Serial or parallel	Serial or parallel
Memory (standard)	512K bytes	1 megabyte	272K bytes	640K bytes
Memory (as reviewed)	2.5 megabytes	1 megabyte	656K bytes	640K bytes
Accessory prices	Font modules (20+): $150 to $330 each Download font disks (16): $200 each Memory boards: 1 megabyte: $495 2 megabytes: $995 4 megabytes: $1995	Download font disks: $150 to $195 each	Memory module, 384K bytes: $300 Additional Personality Modules: $200 each Multiuser Personality Module: $600	Memory board, 1.5 megabytes: $499 Font cards (15): $149.95 each Emulation cards (2): $169.95 each Large paper tray, 250 sheets: $499
Paper bins	Letter, legal, A4, Executive (7¼ by 10½)	Letter, legal, A4, B5	Up to legal-size	Letter, legal, half-letter, A5, A4, B5
Toner cost	$115 (including drum)	$29.95	$29	$29
Cartridge life	4000 pages	3000 pages	1500 pages	1500 pages
Drum life	(In toner)	10,000 pages	20,000 pages	20,000 pages
Engine life	N/A	300,000 pages	180,000 pages	180,000 pages
Documentation	*Getting Started With LaserJet Series II*; user's manual	User's manual; programming manual	Setup guide; printer handbook; software handbook	User's manual
Size (in inches)	18 by 19 by 8½	17¼ by 17½ by 13½	16 by 16½ by 9	16 by 16½ by 8½
Weight	50 pounds	65 pounds	37.8 pounds	35 pounds

bar graph placed in the middle of the memo.

The full-page graphics test used another bar graph, this one generated by Freelance Plus. This software package supports a variety of laser printers and prints at 300 dpi regardless of the memory available to the computer.

Emulation and Graphics

The full-page graphics test provided the opportunity to test the emulation compatibility of each printer. The LaserJet did no emulations; it is a de facto standard that the others try to emulate. The Epson, Okidata, and Kyocera printers all support the Hewlett-Packard and Epson emulation. The emulations are complete, except that the Laserline 6 could not produce graphics with Framework, although this package supports the Epson MX, which the Laserline emulates.

To create graphics images, your software must have the appropriate printer-driver software, and the printer must have enough memory to handle the graphics file. A rule of thumb is that 1 megabyte of memory is sufficient to support a full page of 300-dpi graphics.

The software packages that I tried used different methods to create the image that was sent to the printers. Framework generates the graphics image entirely in the computer's memory. On the 640K-byte Tandy 1200 HD, Framework could produce high-resolution images of only about 1½ by 2½ inches, regardless of the memory available in the printer. Freelance Plus builds the images in parts, and downloads one part to the printer before continuing with the next. Building and downloading images is not fast. A 300-dpi image took about 45 minutes to print on all the printers, and nearly all this time was taken up by the computer creating the image and sending it to the printers.

The time required to build and download an image is directly related to the resolution: A 150-dpi image takes only about 20 minutes, and a 75-dpi image

continued

about 10 minutes. Of course, the time spent waiting is also directly related to the speed of the computer.

Status Messages and Manuals

All the printers have some method for displaying their status—either a front-panel display or a printed status sheet. The LaserJet has a single-line 16-character LCD screen that is informative and easy to read and use. All the machines except the GQ 3500 can also print a status page. This page lists the current status of the printer, the available fonts, and the interface settings.

Each of the printers comes with a user's manual. These manuals share one trait: They are woefully lacking in examples of how to use the special features of these printers. For example, the instruction for printing multiple pages in the Epson manual is a very terse ASCII code: ESC m n. That's all, except for a repeat in decimal and hexadecimal code, and a note that you can't print more than 99 copies. There are no examples. Of course, most BYTE readers can figure out how to send an ESC m to the printer by writing a program in BASIC, but the method of setting the number of copies is not readily obvious. That *n* could stand for almost anything, from the decimal number 30 (for 30 pages) to Roman numerals. As it turns out, it's supposed to be an ASCII character, such as CHR$(30), but this is explained in an entirely different section. An unskilled user might never figure it out. While the Kyocera user's manual has some examples, it could use more. The other manuals are much worse. They are not adequate for an inexperienced user.

Hewlett-Packard LaserJet Series II

HP laser printers are the standard against which other laser printers for PCs are judged, not necessarily because it's the best, but because it is the most common. The Series II is the latest in the HP model line. It is smaller and less expensive than its predecessors, but it is just as fast, and it supports the same software as the earlier versions.

The LaserJet is rated at 8 ppm. In testing, it approached that speed only when printing the same page 30 times. It churned out the 96K-byte document in just under 5.5 ppm, and, in fact, took longer than either the Laserline 6 or the GQ 3500, which are rated at only 6 ppm. (Hewlett-Packard replied that the speed of the laser printer depends on the interaction of the software and hardware. Different system configurations produce different times.) The LaserJet was also no faster than the Laserline 6 or the GQ 3500 in the other benchmarks, with the exception of printing multiple copies of the same page.

The LaserJet is easy to use. The LCD readout gives you a menu of functions and fonts, and you can rotate through them and choose what you want. Unfortunately, the manual fails to mention that you have to turn the printer off and back on again for the choices to take effect.

Because of the LaserJet's generally good documentation, getting the printer installed and operating is a snap. The instructions and drawings lead you through installation of the toner/drum cartridge and hookup to the computer. As part of the installation process, the documentation shows you how to install the font cartridges and how to run the status sheets. The LaserJet gives you a status report that can run to several pages if you print out all the internal fonts.

The LaserJet has the largest selection of optional font cartridges and font disks. The font cartridges ($150 to $330 each) are easy to use; you just plug them in and then select them from the menu. The font disks ($200) let you download a font from your computer to the printer as needed.

HP includes a utility program with the LaserJet to send an individual font to the printer and to print a test page. You can do only one font at a time, and the download process is rather time-consuming. In addition, downloaded fonts take up memory space that otherwise could be used for storing a graphics bit image.

Another utility available for LaserJet users is called PCLPak. This software takes advantage of what HP calls its Printer Command Language. HP says that PCLPak runs on HP and IBM computers. I did not test it for this review.

HP does not indicate the life of the LaserJet; the company says that, with routine maintenance, the engine should last indefinitely. The average life for a toner/drum cartridge is 4000 pages. This is longer than in earlier models of Canon-based printers and is due to a new compact Canon engine (the LPB-SX).

The new engine also provides a new paper path. The pages are stacked face-down in correct order. The paper path takes a U-turn, so not all paper and envelopes will work, but a straight-through paper path with no turns at all is also available.

The LaserJet is a very quiet printer and consumes relatively little power. In fact, the standby power requirement is only 170 watts, which is well within the range of most home wiring systems, as is the printing power requirement of 870 W.

Kyocera F-1010

The F-1010 is the fastest, largest, heaviest printer discussed in this review; it's also the most flexible, and the most expensive. The F-1010 has been available longer than the others, and it uses Kyocera's proprietary engine. It emulates the LaserJet and the Epson FX-80, as well as the IBM Graphics Printer and Diablo, Qume, and NEC daisy-wheel printers. Its printer-control language, Prescribe, lets you include printer commands in text files instead of having to write programs in BASIC. The F-1010 supports a number of graphics and shading primitives, does graphs and charts by itself, and even does bar codes.

The F-1010 is rated at 10 ppm, a claim supported by the machine's benchmarks; thus, it is significantly faster than the other machines reviewed here. It also gets running in a hurry.

Installing the F-1010 is slightly more complex than the LaserJet, because the F-1010 uses a separate toner and drum. You have to install each of them, in addition to removing some packing material and installing a waste toner bottle and a cleaning pad. The toner cartridge and developer unit fit beneath a door on the top of the printer. The drum fits into the side, and the bottle and cleaning pad go inside. The waste toner bottle includes a cap so you can dispose of it without mess, but there is no provision for storing the cap.

The printer is relatively easy to operate. Setting printer attributes, such as the number of copies to print, is different from other printers, since there is no LCD readout. Instead, you can embed commands in text. You don't need to send escape codes. Printer control codes are preceded by the text sequence !R!, which is unlikely to be duplicated in normal text. Using this method, you can easily change typefaces, text size, and other printer attributes from within documents. You can also use a series of batch files from MS-DOS to set the printer up the way you want it.

The F-1010's control panel has a two-digit status display and several warning lights. Kyocera includes a quick-reference panel to help interpret the status codes on the display.

The Kyocera user's manual includes a respectable number of examples and is by far the most thorough manual of all the printers covered in this review. Most of the commands have adequate examples.

The printer also comes with the Prescribe programming manual, which tells you how to use the Prescribe printer-control language. With Prescribe, you can generate pie, bar, and line graphs by simply specifying the type of graph and the data points. The HP download fonts also work with the F-1010.

The F-1010 has an automatic page-

continued

ejection feature. After a user-specified time during which data is not received, the F-1010 automatically prints a page, even if there is no command to do so. You can select a time from 0 seconds up to 8½ minutes, or you can turn off the feature.

The F-1010, like the LaserJet, stacks the pages in a face-down pile in the order in which they were printed. The curl of the pages is slightly tighter than with the LaserJet, and a page will sometimes push the page beneath it out of the stack. There is no straight-through paper path.

The F-1010 will handle an enormous amount of paper. According to the company, the estimated life of the engine is over 300,000 pages. The toner lasts for about 3000 pages, but with the F-1010 you don't replace anything but the toner, which costs about $30. The drum can last for as long as 10,000 pages.

The F-1010 is a heavy-duty printer, and it shows. The machine weighs 65 pounds and requires 950 W maximum power. The cycling of its heaters causes lights sharing its circuit to flicker.

Okidata Laserline 6

At $1995, the Laserline 6 is the least expensive printer in this review. The price includes the required single-user Personality Module. The Laserline 6 emulates the LaserJet, as well as the Epson MX-80, IBM Graphics Printer, Diablo, NEC, and Qume. It is rated at 6 ppm.

The Laserline 6's Ricoh engine lives up to its rated speed. The benchmarks for this printer supported its speed claims, both in the 96K-byte document and in the single page repeated 30 times.

In some ways, the Laserline 6 was the easiest printer of the group to use. While it lacks an LCD screen, it comes with the LaserControl memory-resident utility program for the IBM PC and compatibles, which gives you complete control of most of the commonly used functions.

From the main menu you can choose the emulation you want to run, margin settings, font settings, download fonts, paper size, number of copies, and page orientation, among other things. The software even makes suggestions for the proper settings for various software packages. LaserControl will also support screen dumps of graphics images.

LaserControl supports HP download fonts, and these fonts work fine with the Laserline 6. The software keeps track of the subdirectory where the fonts are kept and downloads one or more of them on request. Unlike the HP software, LaserControl translates the somewhat cryptic filenames into English, so you can pick fonts by name and size.

The printer has a single-digit status display and a series of LEDs that indicate current status. The display panel includes buttons for the self-test and for switching off-line or on-line. The Laserline 6 also prints a status page and font test.

As with the other printers, there should be more examples in the user's manual. The LaserControl software partly compensates for this lack of information, because controlling the printer is somewhat easier with the LaserControl program.

In other respects, the manual is fine. The setup guide leads you through unpacking, installing, and hooking up your printer, in clear steps illustrated by carefully chosen photographs. Installation is easy, even for the novice.

There are a few more steps in getting the Laserline 6 running than there are in the same process for the LaserJet. This is mostly due to the use of the Ricoh engine, in which the toner is separate from the drum. Both of these have to be installed, but it's a simple process, requiring you only to snap the items into place and remove some shipping material. The process is faster and less complicated than for the F-1010.

The LaserJet emulation worked fine with the Laserline 6, but there were problems with the Epson MX-80 and the IBM Graphics Printer emulations. In both emulations, the Laserline 6 could not accept the Framework test file that mixed text and graphics. It would accept graphics for either emulation from Freelance Plus, and it would accept text from Framework and WordStar. Graphics screen dumps worked fine. The problem was with only those emulations and the mixture of text and graphics from Framework. That function worked fine in the LaserJet emulation.

A required Personality Module, inserted into the rear of the printer, provides emulation in the Laserline 6. This module also contains the parallel interface. Optional Personality Modules for serial input ($200) and for a three-person multiuser interface ($600) are also available.

The Ricoh engine that Okidata uses for the Laserline 6 is the same one Epson uses in the GQ 3500. Also, supplies such as toner and drums are easier to find, since they work with both the Laserline 6 and the GQ 3500.

The engine has a paper path similar to that of the LaserJet. Normal operation calls for the paper to be stacked face-down on the top of the printer, but it can be fed straight through and out the other side. The Ricoh engine makes this easy by the use of a knob that controls the paper direction. The engine allows manual feeding and can print envelopes.

The Ricoh engine life is rated at 180,000 pages, and the drum life is

continued

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20,000 pages. The toner cartridge has a normal life of about 1500 pages, which is shorter than the life of toner cartridges in the other printers. According to the manual, some of the toner goes to fill up spaces and channels inside the machine, so the initial toner cartridge lasts only about half that long.

The Ricoh engine's power requirements are comparatively modest—only 600 W at the most; this means the printer can share electrical circuits with other devices. It is also extremely quiet, even for a laser printer.

Epson GQ 3500

The GQ 3500 does not support LaserJet emulation without an add-on card, which was not available for this review. (The HP LaserJet and Diablo 630 emulation cards are now available.) Without emulation cards, you're stuck with Epson LQ emulation, and not all software supports it. Freelance Plus doesn't, so I could not perform the full-page graphics test.

The interface card on the GQ 3500 can be removed to reveal several sets of DIP switches. You can set the switches to emulate either the LQ 1500 printer or a generic, text-only line printer. A change to LQ is advisable if you plan to print graphics. Emulation cannot be set through software control.

Many printer functions must be set by software. This includes normal printer operations, plus those operations unique to laser printers, such as printing multiple copies. The GQ 3500 also allows the definition of circles, boxes, and shading.

The printer has a two-digit LED status display that keeps you posted on the progress of the printer as it warms up and goes through its self-test. It displays a combination of numbers and symbols, which can be translated using a function table on the top of the printer or a reference section on the control panel. The reference section is printed in dark-green letters on a black background and is difficult to read from a distance. The printer does not print a status page.

The speed benchmarks were similar to the Laserline 6's, reflecting the commonality of the Ricoh engine. While each test took a couple of seconds longer than on the Laserline 6, the claimed speed of 6 ppm was supported. The other details of the Ricoh engine operation are shared with the Laserline 6 and have been discussed in that section.

The Epson GQ 3500 is quiet and works well, but it misses the mark when compared to the competition. The lack of standard LaserJet emulation, or even Epson MX or FX emulation, is a serious handicap.

Final Printout

Laser printers are adding functions and dropping in price. The Okidata Laserline 6, Epson GQ 3500, and Hewlett-Packard LaserJet Series II are certainly examples of that, and they provide excellent value. The Kyocera F-1010 looks instead to features and speed, as well as an extremely long life. All these printers perform adequately.

Before choosing a laser printer, you must first determine your needs. Do you need fast text output or graphics? Will the software you use support a particular printer? Is there an upgrade path that will let you add fonts or memory to the printer? Because of the proliferation of new laser printers, you'll have to carefully examine the specifications for each. ■

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (1777 North Kent St., Arlington, VA 22209), where he consults with the federal government on microcomputers.

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Three C Language Screen-Utility Packages for PCs

Jonathan Robie

A look at the Windows for Data, C-Worthy, and Vitamin C screen utilities

Writing an easy-to-use interface for a program accounts for a large part of the time spent developing applications, and it often accounts for the majority of the code. Screen utilities provide the programmer with high-level tools for developing windows, menus, and data prompts. The look and feel of the user interface in a prototype program can be rapidly modified because these packages supply libraries of ready-to-use screen and keyboard functions. Appropriate inputs from the user cause the library functions to call core functions that accomplish the program's purpose. Once all parties agree on the user interface design, the core functions can be written, tested, and integrated into the program.

The products reviewed here all provide for menus, data-entry forms, on-line help, and keyboard and windowing functions using the C programming language. Although they allow some flexibility in program design, these packages also make assumptions about the user interface that can be different from your own. You can obtain the source code for each product (usually at additional cost) and modify it to suit your needs. All three companies allow you to develop commercial programs with their packages without having to pay royalty fees.

The Packages

Vermont Creative Software's Windows for Data version 2.05 was built using the Windows for C version 4.12 windowing library, and the two packages together cost $395. I received both Windows for Data and Windows for C for this review, and I will treat them as one package. A free demonstration disk is also available. The two packages together including source code costs $1290. Although the package I reviewed is for use with MS-DOS, you can obtain versions that support the Unix, Xenix, and VMS operating systems.

Custom Design Systems' C-Worthy Library version 1.0 is marketed by Solution Systems and costs $295. C-Worthy is available with source code for $495. A free demonstration disk is available, and it contains the tutorial on disk. C-Worthy also supports a variety of MS-DOS computers that are not IBM PC-compatible (e.g., the TI Professional, Victor 9000, NEC APC III, and NEC PC 98) through the use of machine-specific overlays.

Vitamin C, from Creative Programming Consultants, costs $225 and includes the source code. It comes with two demonstration disks. If you return it within 30 days and have used only the demonstration disks, the company will refund your money. If you need source code for your program development, then Vitamin C will be significantly less expensive than the other packages.

I tested these products on an Epson Equity II computer with an NEC V30 CPU, 640K bytes of RAM, and a 20-megabyte hard disk drive. All three packages require a minimum of 256K bytes of RAM, and a hard disk drive is recommended for program development.

Windows

The data-entry, menu, and help facilities of these programs are built on extensive windowing libraries. Windows for Data's windowing libraries are sold as a separate product called Windows for C, which comes with its own manual. The other two programs document their windowing routines along with other routines. All three programs support multiple pop-up windows with borders and titles, text display with automatic word wrap and scrolling, and assignment of display attributes to a window.

C-Worthy and Vitamin C support virtual screens—windows that are larger than the screen display. You can only view as much of the contents as will fit in the screen display at a given time, so C-Worthy has a function that lets you scroll through the window manually, and Vitamin C automatically adjusts the window so the text at the cursor position is always visible. Windows for Data does not support virtual screens per se, but provides the same functionality through memory files. The term *file* is misleading: A memory file is an array of pointers to strings associated with a window that are treated like a file. These strings reside in the computer's memory for fast access. A function is provided that lets you scroll through the memory file and return control to the program by hitting the Escape key.

Keyboard Handling

I was pleased with the powerful keyboard-input routines in all three packages. Each lets you associate a function key with a C function that's executed whenever the keyboard-input routines detect a key press on the associated key. For example, in Windows for Data, you can define the F2 key to display a help screen by using `keyd_def(-K_F2, kdhelp())`, where `kdhelp()` is a help function. Each package supports keyboard-idle functions—user-written functions that execute whenever the input function doesn't detect new keystrokes for processing. A keyboard-idle function might be used to update the time display on the screen.

Only Vitamin C supports keyboard handlers and keyboard reassignment. Keyboard handlers are called prior to the Vitamin C input functions, allowing the handler to perform text filtering or conversion. The programmer can also reas-

continued

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sign the keyboard definitions at run time. For example, the text editor has its own table of keyboard definitions, so you can have one set of assignments for the text editor and one set for all other data entry.

Menus

All three packages have high-level routines for creating and processing menus. Table 1 lists some of the menu features of these packages. Each package stores menus as a linked list of menu items. The first step to using a menu is to initialize the menu structure. In Windows for Data, the size and attributes of the menu are specified with this call. Vitamin C defines a menu style, then specifies that style in the initialization call. Since C-Worthy automatically determines the size, placement, and attribute of the menu, you simply declare the beginning of a list.

The second step is to declare the items on the menu. Windows for Data specifies the relative coordinates for each menu item and gives pointers to functions or submenus that are activated when the item is chosen. Vitamin C positions the items automatically within the menu, but, like Windows for Data, requires the programmer to specify the menu function in the definition call. C-Worthy takes a different approach: Instead of defining a function for each item, it calls a general-purpose function when the item is selected. This function handles all menu choices and has a single input parameter that stores the user-selected item. Other functions can be called or additional menus defined within this function.

The third step is to call a menu-processing function. In all three packages, this function handles the chores of highlighting menu choices, moving the cursor, and returning the user's response. The menu-processing function regains control after the item functions are called, and an item function can return a value to signal the menu processor to stop the program.

Although Vitamin C provides more options for pop-down and pull-down menus, Windows for Data places the menus on the screen automatically. This is a great convenience, because the placement of secondary menus depends on the location of the items on the primary menu, and Windows for Data will adjust the secondary menus automatically when the primary menu is altered. Like the other packages, Windows for Data lets you select a menu item by typing the first character, but, unlike the others, it does not allow the programmer to require confirmation. This makes it possible to develop menus where you accidentally make choices by hitting the wrong key.

C-Worthy does not provide pop-down or pull-down menus. Instead, C-Worthy automatically centers all menus on the screen and uses windows to display them. The active menu is highlighted by the menu-processing routine. This means that menus developed with C-Worthy have a consistent appearance, and it is easy to develop the menus because much of the work is done for you.

Table 1: *Menu options for the three packages. Vertical menus are menus in which the items are arranged from top to bottom. Lotus-style menus are horizontal; items are placed next to each other on a line. A pop-down menu is a pull-down menu that displays its contents without requiring a pull-down action. Pop-up and pull-down menus are two different ways of providing a second-level menu: Pop-up menus are displayed automatically when the item on the primary menu is selected; pull-down menus are displayed when the user highlights the item and requests the second-level menu with the Return key or the down arrow. Menu-level help is context-sensitive help that explains how to use the current menu; item-level help explains only the currently highlighted item. Item-level prompt strings are one-line prompts that appear when an item is highlighted to explain the purpose of the item. Initial character selection allows the user to choose an item on a menu by typing the first character. Default placement positions the menu on the screen without having the position specified by the programmer; manual placement allows the programmer to specify the location of the menu. A menu-processing function is a function that displays and controls the menus, calling the appropriate functions when choices are made. Check marks are marks that appear next to items on a menu to indicate program status. Separators and blank items are formatting options used to group items on a menu. Unavailable items are used to indicate that some options are currently inactive and cannot be selected.*

Menus	Windows for Data	C-Worthy	Vitamin C
Vertical	Yes	Yes	Yes
Lotus-style	Yes	No	Yes
Pop-down	Yes	No	Yes
Pop-up	Yes	Yes	Yes
Pull-down	Yes	No	Yes
Menu-level help	Yes	Yes	Yes
Item-level help	Yes	No	Yes
Item-level prompt strings	Yes	No	Yes
Initial character selection	Yes	Yes	Yes
Default placement	[1]	Yes	No
Manual placement	Yes	No	Yes
Menu-processing function	Yes	Yes	Yes
Check marks	No	No	Yes
Separators/blank items	No	No	Yes
Unavailable items	No	No	Yes

[1] For secondary-level menus only.

Data-Entry Forms

The three packages take different approaches to defining data-entry forms, which are displays that prompt the user for data. C-Worthy and Windows for Data treat forms much like they treat menus: First you define the form, and then you add fields and text strings to it. Finally, you call a function that handles the user's interaction with the form and stores the response. The form is stored as a linked list in both packages.

Vitamin C doesn't have data-entry forms; instead, it defines a set of fields and their relative placement within the current window. The `atsayget()` function positions the cursor, prints the prompt string, and sets up the data-entry field. All input fields are placed in a "get table." The function `readgets()` controls all user input based on the entries in the get table, and then deletes all entries from the table when data entry is finished.

You must specify the form's coordinates in Windows for Data when the form is defined. Next, you specify the location of every field. You can define the prompt and the field in one call, and the field is automatically placed next to the prompt. However, you can corrupt memory if the placement of the fields is not consistent with the size of the form. This is an easy mistake to make, as the form size must be

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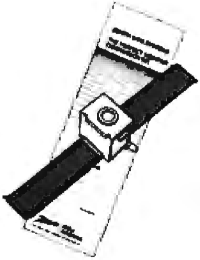

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somewhat larger when you are using borders. For this reason, it's important to use the debugger during the development of data forms, because it catches this type of error at run time. Some help is available from the Forms Design utility, a simple program that lets you design forms by drawing them with a text editor.

In C-Worthy you must specify the lo-

continued

Table 2: *Data forms and field options for the three packages. I have used* Windows for Data*'s terminology.* Autoexit *ends form processing after the last field is entered. For* Automove*, the cursor is automatically advanced to the next field when the current field is full. Normally the user must enter data by filling the fields in the order they are presented on the screen.* Cursorfree *lets the user enter data by moving the cursor to any field in any order.* Noecho *fields do not echo data to the screen.* Initialblanks *initializes all data-entry fields to display blanks before data is entered. The* clear *attribute clears the input field when the first printable character is entered. If a field is* required*, then some data must be entered in the field; if it is a* mustfill *field, then the entire field must be filled. A* picskip *field strips all formatting characters before returning the variable: For example, a phone number entered as (517) 353-9297 would be returned as 5173539297. Data in a* protected *field cannot be changed. The* skip *attribute means the cursor is never placed on the field. Data in a* rtadjust *or* lftadjust *field is right-justified or left-justified upon exit. A* rtentry *field lets a user enter numbers from right to left, as on a banking machine.* Trailblanks *specifies that blanks at the end of the string are to be retained as data.*

Forms and Fields	Windows for Data	C-Worthy	Vitamin C
Picture clauses	Yes	Yes	Yes
Predefined types			
string	Yes	1	Yes
extended string	Yes	Yes	No
date	Yes	Yes	Yes
time	Yes	Yes	No
Boolean	Yes	Yes	No
integer	Yes	Yes	Yes
longint	Yes	Yes	No
fixed-point	Yes	Yes	No
float	No	No	No
double	Yes	Yes	Yes
scientific notation	Yes	No	No
multiple choice	Yes	Yes	Yes
text edit	No	Yes	No
menu field	No	Yes	No
Form attributes			
user-defined validation	Yes	Yes	Yes
user-defined evaluation	Yes	Yes	Yes
user-defined control	Yes	Yes	No
Field attributes			
autoexit	Yes	Yes	Yes
automove	Yes	No	Yes
cursorfree	Yes	Yes	No
noecho	Yes	No	No
initialblanks	Yes	No	No
clear	Yes	Yes	Yes
required	Yes	Yes	Yes
mustfill	Yes	No	No
picskip	Yes	Yes	No
protected	Yes	Yes	No
skip	Yes	Yes	No
rtadjust/lftadjust	Yes	Yes	No
rtentry	Yes	Yes	Yes
trailblanks	Yes	No	Yes

1 All string processing is extended-string processing.

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Name	Windows for Data version 2.05/ Windows for C version 4.12	C-Worthy Library version 1.0	Vitamin C version 3.0
Type	Screen utilities	Screen utilities	Screen utilities
Company	Vermont Creative Software 21 Elm Ave. Richford, VT 05746 (802) 848-7738	Solution Systems 541 Main St., Suite 410 South Weymouth, MA 02190 (617) 337-6963	Creative Programming Consultants P.O. Box 112097 Carrollton, TX 75011-2097 (214) 416-6447
Format	4 double-sided, double-density 5¼-inch floppy disks	5 double-sided, double-density 5¼-inch floppy disks	6 double-sided, double-density 5¼-inch floppy disks
Computer	IBM PC or compatible with at least 256K bytes of RAM	IBM PC or compatible or several noncompatible MS-DOS machines with at least 256K bytes of RAM	IBM PC and compatibles with at least 256K bytes of RAM
Hardware Required	Hard disk drive recommended	Hard disk drive	Hard disk drive
Software Required	Microsoft 4.0; Lattice 3.0 or higher; Aztec 3.40A or higher; Computer Innovations 2.3 or higher; Turbo C 1.0	Microsoft 3.0 or 4.0; Lattice 2.15 or 3.00; Aztec 3.4 or higher	Microsoft 4.0; Lattice 2.15 or 3.0; Aztec 3.20E; Computer Innovations 2.30; Datalight 3.0; Turbo C 1.0
Language	C	C	C
Documentation	426-page *Windows for C Reference Manual*; 428-page *Windows for Data Reference Manual*	485-page *C-Worthy Library*; documentation on disk	360-page *Vitamin C User's Guide/Reference Manual/Tutorial*
Price	$395 for Windows for Data and Windows for C; network for up to five users, $1185; with source code, $1290; free demo disk available	$295; with source code, $495; free demo disk available	$225 with source code

cation for both the prompt and the field. This doubles the number of function calls needed to define an average form, and you must modify the field placement any time the text of the prompt is changed. The text in the prompt string, like text in menus, is defined within a message librarian, which defines a symbolic constant used in your program whenever you wish to invoke the text. This allows text messages to be changed without recompiling the main program, and it makes it much easier to change the text to different languages. Unfortunately, this means that the actual text of the message is not visible when you are writing the calls to define the form, making it difficult to place the field properly. Table 2 lists the most important field-entry features of the three programs.

User-defined input functions allow your program to accept input in formats that you define yourself. This is convenient if the library's input format doesn't suit your data-entry needs. There are a number of ways to process form data fields, but generally they can be classified as control options, validation options, and evaluation options.

An example of a control option is a picture clause. A picture clause uses a control string that specifies what characters can occupy a given position in the field. For instance, if the digit 9 in the control string means that only a digit can be entered in the position, then the picture clause 99/99/99 allows pairs of digits to be entered between slashes for entering a date.

Validation functions specify what type of input is considered valid. The picture-clause example given for dates does not force you to enter a valid date: You could enter 89/88/00. A validation function corrects this type of data-entry error.

Evaluation functions determine what value should be stored in the data variable based on the validated contents of the input field. As an example of this, none of the packages accept fractions as floating-point numbers. However, one user might enter the value 0.5 in decimal notation, and another user might enter the value as a fraction (½). If you can define a data type that allows the use of either format, you can avoid forcing the user to convert values from one form to the other.

C programmers will recognize most of the types in table 2, but a few deserve special mention. Extended strings are strings that can include any extended ASCII character, which is useful when processing foreign language input. Multiple-choice fields present a list of options from which the user chooses. Text-edit fields call up a text editor and allow simple word processing in a window. The final results are returned to the program as a string.

Windows for Data supports significantly more form and field attributes than the others, and it supports all the predefined types except float, text-edit fields, and menu fields. C-Worthy provides extensive support for predefined types, and the text-edit field is useful when trying to make your data-entry forms fit on the screen. Defining forms is awkward, however. Vitamin C is relatively poor in features, but the syntax for defining forms is simple and intuitive. The programmer can add most of the missing features through programmer-defined routines that can be associated with the fields.

Additional Features

The context-sensitive help facilities of the three programs are similar. Windows for

Data and Vitamin C place all help messages in a file, where they are indexed on a keyword. Special characters indicate the keywords, and all text between keywords is assumed to be a help screen. Keywords are specified when defining menus, items, forms, and fields, and are used to access the relevant help text.

Windows for Data provides a function that reads the help file into memory so the program can use it; Vitamin C provides a utility that indexes the help file so it can be accessed efficiently. C-Worthy has a special utility, called the help librarian, that is used to define help text for the application. All three packages allow help text to be defined and implemented quickly and painlessly.

C-Worthy and Vitamin C both include simple text editors that you can incorporate into your programs. This can be extremely useful in programs that accept free-form text input: You simply define a window and call the editor. They have a good set of basic features: Both provide general cursor-positioning functions, word wrap, and cutting and pasting. Vitamin C also has a search function.

Strengths and Weaknesses

All three packages are suitable for professional programming and for the overall design of user interfaces. You will become more productive using any one of these programs, and I did not find one to be clearly superior to the others. Your taste and needs will be important factors in choosing a package. Demonstration disks are available separately for C-Worthy and Windows for Data, and I encourage you to obtain them if you want to evaluate these products. Vitamin C is available on a 30-day trial basis.

Windows for Data gets high marks for flexibility in forms, and it is good at menus (although not quite as flexible as Vitamin C). Windows for C provides extensive windowing facilities that can give your application a professional look. Windows for Data has a rich set of routines that will not restrict you if you know how you want your screens to appear.

Vitamin C provides the most options for menus. Macintosh fans will be pleased with its ability to duplicate the menus found on that machine. It would be more difficult to implement Macintosh-style menus with the other packages. Vitamin C is fairly weak in handling forms, as it provides only a few field types and relatively few field options, but the form-handling functions are easy to use and will be familiar to dBASE programmers. If you want source code, Vitamin C is the least expensive, and it is probably adequate for most users.

C-Worthy does not have as many options as the other packages, but its predefined menu styles allow development of attractive applications with less effort than the others. C-Worthy's screens are quite striking, and I found myself imitating them when working with the other packages. However, C-Worthy is good only as long as you stay within its predefined formats. If you want high-level support for a variety of custom menus, C-Worthy will not be of help. On the other hand, if you intend to translate your program for use with foreign languages, you will appreciate the fact that in C-Worthy, all text is managed by the librarians and can be changed without modifying the program. ■

Advantage C++ and Guidelines C++

by Mark Mallett

Advantage C++ and Guidelines C++ are two of the first PC implementations derived from the AT&T C++ translator developed by Bjarne Stroustrup.

C++ is a strict superset of C that adds facilities for data abstraction, in-line functions, and function prototyping. Inline functions let you avoid the overhead of procedure calls. Function prototyping ensures that procedures are used the same way they are declared.

The new features in C++ mainly support classes that give you the ability to define new data types and operators or to redefine already-existing operators (operator overloading). A class is a description of data. It can include how the data is stored, as well as how, or even whether, the data can be accessed. A class can be derived from another class (base), in which case it inherits some or all of the properties of the base class.

Advantage C++ version 1.1M3 (Lifeboat Associates, $495) and Guidelines C++ version 1.1 (Guidelines Software, $195) each require an IBM PC, XT, AT, or compatible. A hard disk drive and 640K bytes of RAM are recommended.

C++ compilers are often referred to as translators because they produce C code, not assembly language or binary output. Thus, you must also have a C compiler. Advantage C++ works with either the Lattice compiler (version 3.0 or higher) or Microsoft C (version 3.0 or higher); Guidelines C++ requires Microsoft C (again, version 3.0 or higher).

For this review, I used an Intelligent Micro Systems PC AT–compatible computer running at 10 megahertz, with 3.5 megabytes of RAM and a 42-megabyte MiniScribe 28-microsecond hard disk drive. I used Microsoft C version 4.0, with MS-DOS 3.1.

The main differences between these two implementations are in the documentation, the front end, and the price. I did not find any significant differences between the libraries supplied.

Starting Up

The bulk of the documentation for both packages consists of Stroustrup's book, *The C++ Programming Language* (Addison-Wesley, 1986). Advantage C++ comes with a bookshelf-style box and binder, with some excerpts from AT&T release notes, a small amount of introductory material from Lifeboat, and some discussion of future packaging plans. A small, nicely printed user's guide is also included, but it doesn't say much that isn't said in Stroustrup's book. Guidelines C++ documentation consists of essentially the same AT&T release notes, bound in a full-size three-ring binder. The print quality leaves much to be desired; most of the pages are poor-quality photocopies.

Installing either package is amazingly painless. For each, you insert the first of two disks and type `install` with the appropriate parameters, and after awhile you insert the second disk and hit Return. After that, you may have to do some minor tinkering to set environment variables that C++ uses to find directories.

One complaint that I have is that, unless you specify otherwise, the Advantage installation program puts some of its files (executables and include files) into the directories used by the C compiler (Microsoft's, in my case). I prefer to keep different packages totally separate. Another complaint is that, to avoid name conflicts with the C compiler's files, Advantage gives some of its include files the extension .HXX. I'd rather have standard include-file extensions, so source files

continued

Advantage C++ version 1.1M3

Type
Translator

Company
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55 South Broadway
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Hardware Required
IBM PC, XT, AT or compatible with at least 640K bytes of memory (a hard disk drive is recommended); MS-DOS 2.0 or higher; either Microsoft C version 3.0 or higher, or Lattice C version 3.0 or higher

Language
C++

Documentation
Bookshelf-style binder with loose-leaf user's guide, release notes, and *The C++ Programming Language* by Bjarne Stroustrup

Price
$495

Guidelines C++ version 1.1

Type
Translator

Company
Guidelines Software
P.O. Box 749
Orinda, CA 94563
(415) 254-9393

Hardware Required
IBM PC, XT, AT, or compatible with at least 640K bytes of RAM (a hard disk drive is recommended); MS-DOS 2.0 or higher; Microsoft C version 3.0 or higher

Language
C++

Documentation
Full-size three-ring binder with photocopied installation guide, reference sheets, and release notes; *The C++ Programming Language* by Bjarne Stroustrup

Price
$195

don't have to be modified depending on the compiler being used.

These complaints, however, are subjective, minor, and solvable. The installation program lets you specify another directory during installation. Then you can rename all the .HXX files, giving them .H extensions, provided that you keep them in a separate directory from the C compiler's include files.

Translating and Compiling

Both products follow similar steps in turning C++ source programs into executable files. First, the program is run through the C++ preprocessor. This is similar in function to the C preprocessor, removing comments from the source file and handling directives that begin with a #, and providing for insertion of include files, macro definition, and expansion. The output from the C++ preprocessor goes to the C++ compiler itself, which compiles it into C language source code; this is then run through the C compiler. A linker combines the code from one or more relocatable files, along with routines from any run-time libraries used (including, at least, the standard routines supporting the C++ product and the C product used), and produces an executable program.

To control the compilation process, Guidelines provides an array of batch files. For each memory model (small, compact, medium, large, and huge), there are four batch files, each of which takes a C++ source file to a particular stage in the compilation. One batch file runs the source file through the C++ preprocessor; another preprocesses and translates to C source code; a third does these first two steps and also compiles the C source code; and the last carries out the first three steps and then generates an executable file.

The batch files, which are all hidden away in a subdirectory, are named in a way that makes it easy to remember what the names are. You can reference these batch files from a MAKE file; Microsoft's MAKE utility had no trouble with them. Also, the Guidelines documentation includes complete descriptions of how to run each phase of the C++ compiler, in case what you want to do isn't covered in any of the batch files.

Advantage C++ supports small, compact, medium, and large model programs. Instead of batch files, Advantage C++ provides a driver program that automates the compilation program. This program directs the process by invoking the C++ preprocessor and compiler, the C compiler, and, finally, the linker. Parameters to this driver program can specify various options, such as how much of the compilation process to perform, or whether to allow old-style function definitions in order to compile plain C code. These options are given on the command line as a special character, such as a minus sign or an exclamation point, followed by an alphabetic character that identifies the option.

One of the options to this driver program causes it to output the commands that it would execute, without actually executing those commands. You can use this option to build a batch file to be executed later. This is useful when you don't have enough memory to run both the compiler and the driver program plus any program that may be controlling it; in fact, with the programs I compiled, this technique was necessary when using Advantage C++ with Microsoft's MAKE utility.

The command syntax for the driver program is completely documented, but Lifeboat should include specific documentation for the individual compiler phases. The only way to learn the command syntax is to vary the parameters to the driver program, run the program, and output the results to a batch file. Then you must look at the commands that it generates and find the relationship between the options you typed and the command lines it generated.

Debugging C++ Programs

With either product, you can debug the C++ source files with Microsoft's Codeview debugger. Both products ran into problems with Codeview when non-in-line functions were defined in include files. With Advantage, Codeview will not enter into the include file; with Guidelines, it gets stuck in the include file. The Advantage documentation notes this as a flaw in Codeview.

Within Codeview, you must reference variables by their names as output by the C++ compiler, even though the C++ variable names are shown in the source window. Both packages use the same rules for forming these names, and although the names are long and hard to type, the rules for constructing them are easy to figure out. For example, a structure variable called `str1` has a member `mem1`, declared as an integer. If the variable `str1` is on the stack, member `mem1` would be referred to by the name `_auto_str1._INT_mem1:`. The storage class is attached to the beginning of the variable or member name, with underscores in front of each class, variable, and member name.

Messages from the C++ compilers are peculiar at times (especially when inserting in-line functions, from which a lot of `Sorry, not implemented` messages can result), but both products' messages are peculiar in the same ways. In fact, I got both C++ compilers to give me an `Internal error` message.

Both compilers have a habit of generat-

continued

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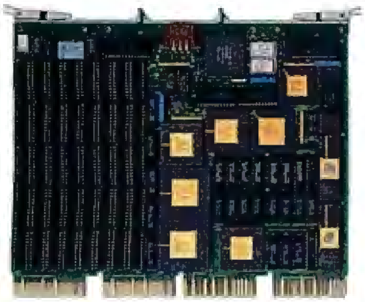

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Table 1: *Operator overloading tests. In this test, I used C++ operator-overloading techniques to change the way basic arithmetic and logical functions were compiled using the BYTE Sieve program without changing the source of the Sieve program itself. "Unmodified" indicates the Sieve program without changes. "In-line substitution" redefines all arithmetic and logical operators, but does so using in-line operator procedures. "External substitution" reimplements all operators by using procedure calls. "External, no registers" is the same as "External substitution," except that the operator functions do not declare their terms to be of class "register."*

	Compile time (in seconds)	Execution time (in seconds)	File size (in bytes)
Unmodified			
Advantage	16	22	8048
Guidelines	15	22	6824
In-line substitution			
Advantage	19	24	8080
Guidelines	18	24	6852
External substitution			
Advantage	21	222	8464
Guidelines	20	224	7220
External substitution, no register			
Advantage	21	217	8448
Guidelines	20	217	7204

ing very long symbol names. This often causes the Microsoft C compiler to issue messages warning that the symbol names have been truncated to the first 32 significant characters. Error messages from the C++ compiler itself (again, both products) do not necessarily refer to source-file lines in order; and although they are usually quite accurate (my favorite was `Perhaps you forgot a ';' after the '}'?`), occasionally error messages have nothing at all to do with the problem.

Finally, both C++ compilers emit spurious unreferenced values in the C code, from null constructors and destructors. Since these are unnecessary, the C compiler filters them out.

Benchmarks

I modified the standard BYTE Sieve benchmark to perform 100 iterations rather than 10. (On my AT, 10 iterations were too fast to measure easily.) I then compiled and ran the benchmarks under both C++ products and compared the results to compiling and running under Microsoft C. Not surprisingly, there is very little difference in code size or execution speed between the two C++ packages. Both packages produce slightly larger executable files than does the Microsoft C compiler by itself; this is to be expected, because of extra start-up and termination code with C++.

One important aspect of type definition is operator overloading—using standard operators, such as + and <, to manipulate variables of user-defined data types. To investigate the performance of operator overloading, I redefined the operators in the Sieve program and compared this to the same program using built-in operators. I chose the Sieve program because, while it makes heavy use of integer arithmetic and Boolean operations, it uses only a small number of different operators. To overload operators, you write C++ procedures to implement each operator.

Taking a cue from one of the exercises in Stroustrup's book, I created a file to be included at the beginning of the Sieve program. This include file defines a class INT, to be equivalent to an `int`, and the appropriate operators for it. Class `INT` looks like this:

```
class INT {
  int val;
public:
  INT( int i ) { val = i; }
  INT() {}
  int operator= (int t2);
  int operator+ (int t2);
  int operator- (int t2);
  int operator+= (int t2);
  int operator++ ();
  int operator<= (int t2);
  operator int(); };
```

This definition defines a class `INT` that contains a single integer value and overloads some arithmetic and Boolean operators. I've also defined a way to convert from class `INT` to type `int`, so that binary operations on two `INT` types will also work. The bodies of all the operator functions are declared apart from the definition of the `INT` class, to make it easier to change them from in-line to non-in-line for this test.

I ran this benchmark in three ways: with the operator functions declared in-line, not declared in-line (external substitution), and not declared in-line but also with their second term not declared as a register variable. (The first term of a binary operator is always declared as a register variable.)

Table 1 gives the compilation time, execution time, and executable file size for each scenario with each C++ system. In this test, the use of in-line procedure substitution cost little in execution time over the original benchmark (24 seconds versus 22 seconds for both products), nor was there a significant increase in file size. The penalty in execution time when in-line substitution was not used is not surprising: The added function-call overhead slowed the execution of the program by a factor of 10 (222 seconds for Advantage and 224 seconds for Guidelines, as opposed to 22 seconds for the base non-overloaded-operator version for both products). Note that when the second operator was not declared as a register variable, the execution time improved slightly. This is also normal behavior in C programs; declaring a little-used variable as a register variable often costs more time to set up the register variable than it saves in accessing the data through a register.

Operator overloading works well and efficiently in both packages. The benefits of operator overloading, and other aspects of data abstraction, include clearer semantics and more reliable code, resulting from the separation of datatype definition and data use. Where operators can be implemented in small functions with in-line substitution, there is very little increase in size or execution time. Where in-line substitution is not used, you must bear the overhead of procedure calls; but keep in mind that implementing the equivalent operations in C involves function calls that must be coded explicitly.

I wrote a more extensive program, called Score, which uses the unique features of C++ to manipulate simple representations of melodies to test the unique features of C++. All song elements are derivatives of a base class, SCORE_ITEM. This program also defines input and output operators for each song element, to test overloading existing operators

continued

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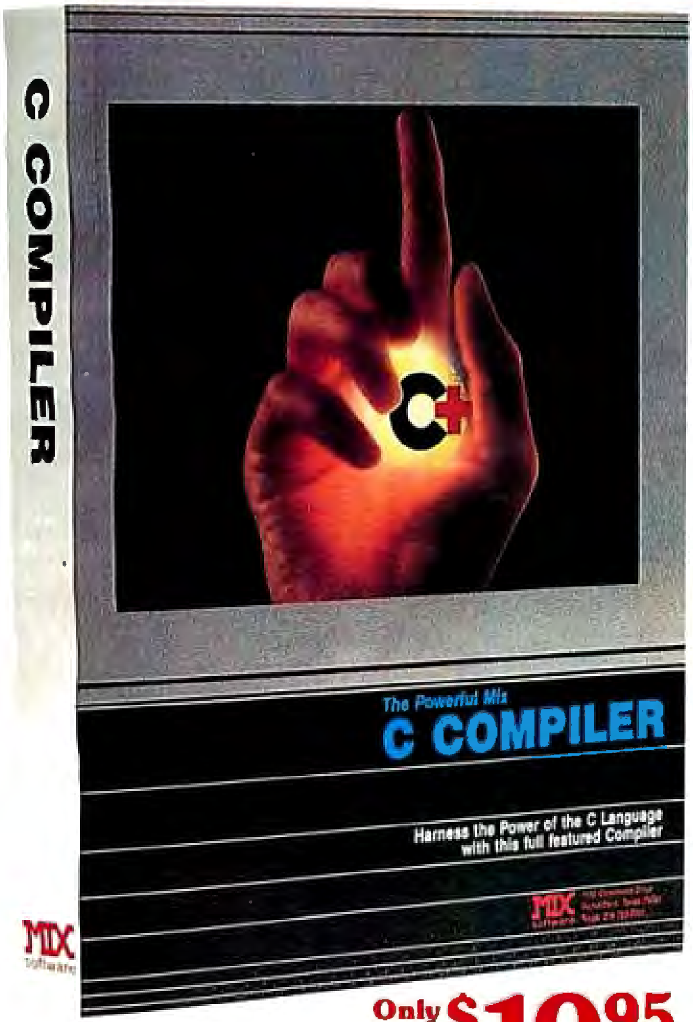

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System Requirements: MSDOS/PCDOS 2.0 or higher; 256K Memory; 1 Disk Drive or CP/M 2.2 or higher (Z80); 55K Memory; 1 Disk Drive (2 recommended) (Ctrace not available for CP/M)

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on already-defined types when new types are defined. It lets the user enter song items (e.g., rests, notes, and chords) using stream I/O (a facility that is part of the C++ library), and then play back the song using a virtual function defined for all items.

Advantage C++ took somewhat longer to compile and link the program than did Guidelines (89.5 seconds versus 81.5), but the executable files that each product produced were nearly the same size: Advantage C++ produced a 31222-byte file, and Guidelines C++ produced a 30308-byte file. Since Score is an interactive program, execution times are not relevant. Both programs performed identically and as expected. [Editor's note: *The source code for Sieve and Score is available on disk, in print, and on BIX. See the insert card following page 304 for details. Listings are also available on BYTEnet. See page 4.*]

Little Difference

C++'s extensions to the C language promote more understandable, reliable, and maintainable programs by providing stronger type-checking (especially concerning procedure definitions and references) and support for data abstraction. Once you have decided that the C++ extensions to C are useful enough to learn, you will want to choose a commercial implementation.

I could find very little difference between the performances of Advantage C++ and Guidelines C++. Both are essentially equivalent in ease of use, execution time, and generated code. Advantage C++ has the edge in documentation, since it comes with many sample source files and all the examples from Stroustrup's book. If you want to use Lattice C, then your only choice is Advantage C++. If you are using Microsoft C, the difference in price ($195 for Guidelines, $495 for Advantage) recommends Guidelines. ■

[Editor's note: *At the time of this writing, Guidelines informed us that version 1.2 would be released this month. According to the company, it will include professionally printed documentation and more example programs on disk, and will cost $295. Lifeboat was also scheduled to come out with version 1.2 last month; according to the company, version 1.2 will have Microsoft Windows compatibility and improved documentation.*]

Mark Mallett is a 10-year computer veteran with interests in systems, graphics, database, mail, and conferencing software. He can be contacted at Zinn Computer Co. (Litchfield, NH 03103.)

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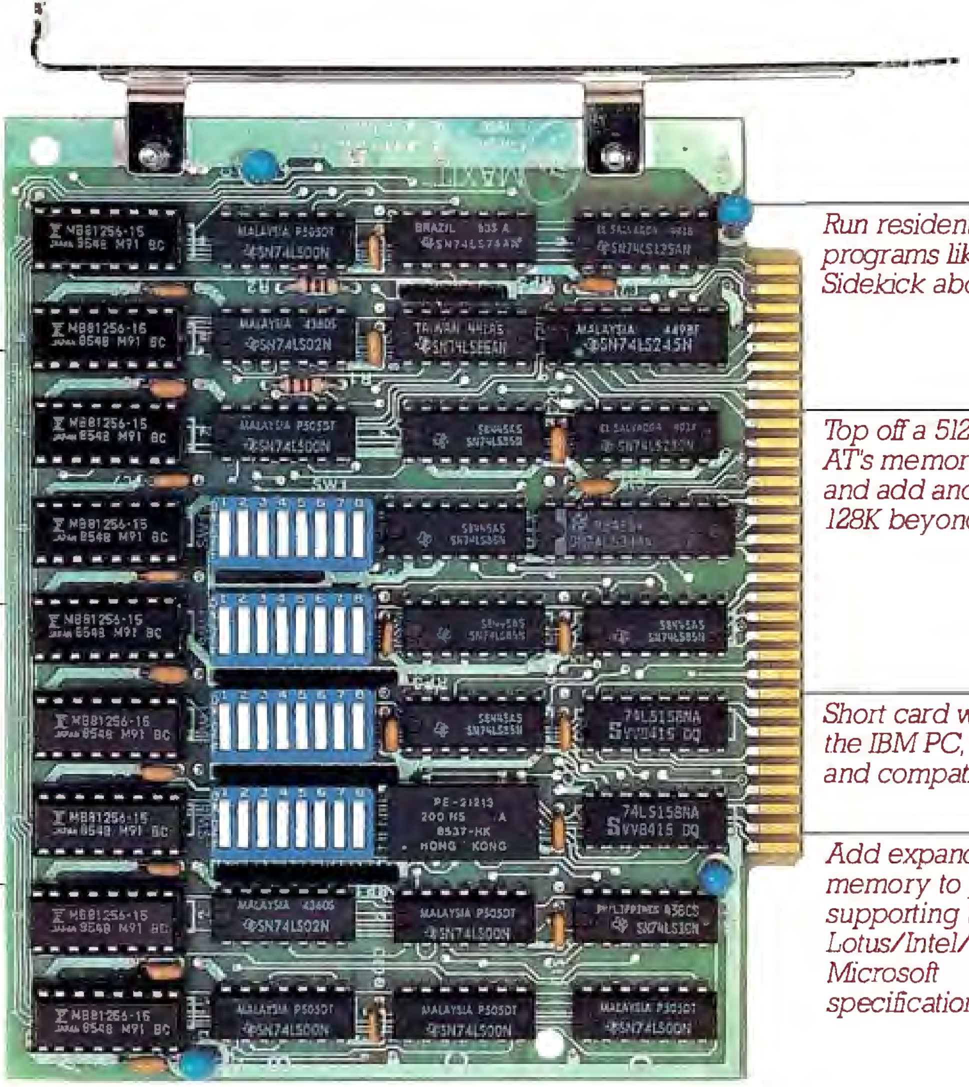

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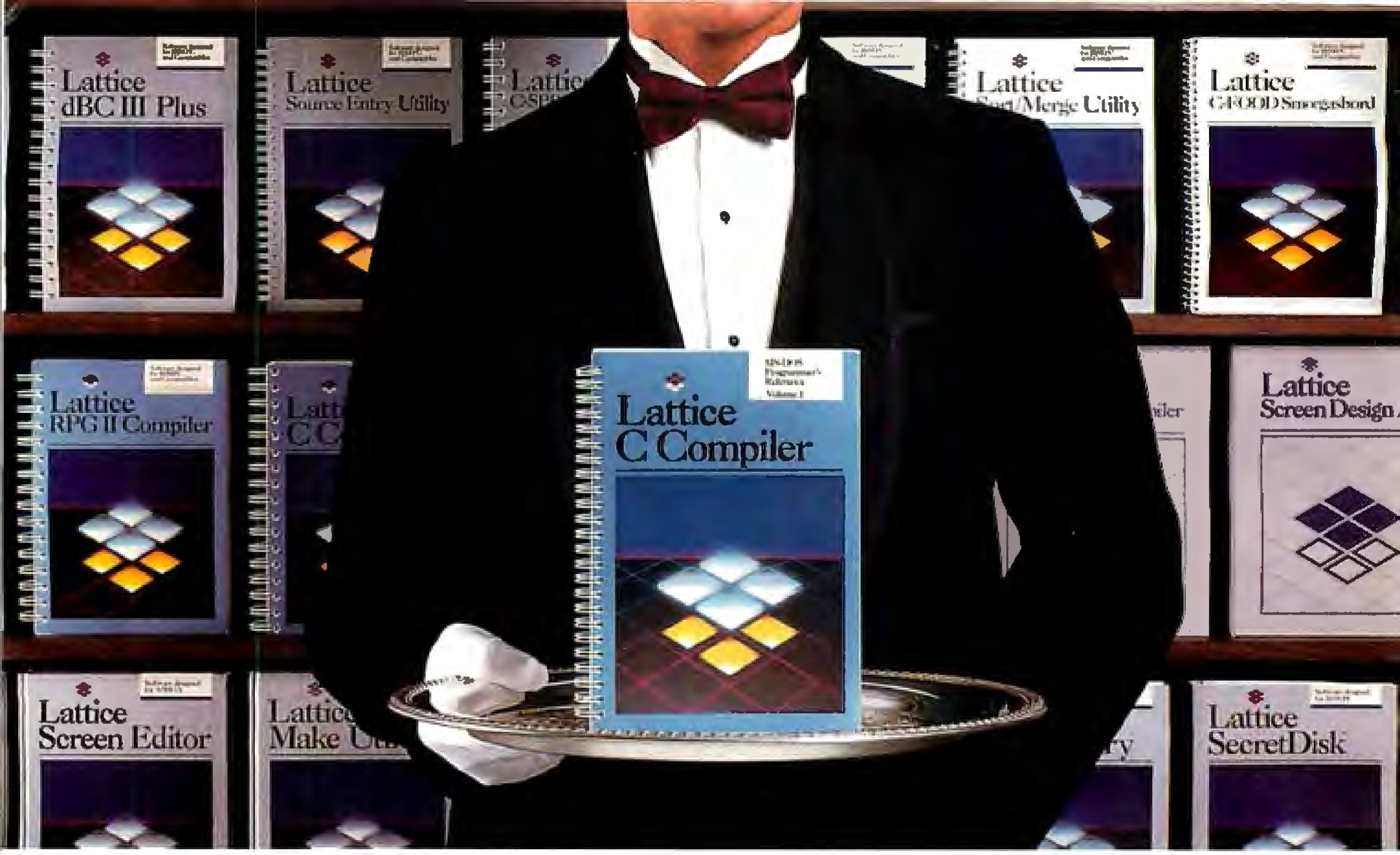

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Equation Solvers

by George A. Stewart

Eureka and TK Solver Plus do mathematical computing without programming

Eureka and TK Solver Plus offer two very different approaches to equation solving on computers.

Eureka 1.0, a $167 MS-DOS package from Borland International, is easy to use and is a good educational tool for any field involving mathematics, but it is limited in its suitability to realistic mathematical applications. (For instance, equation files are limited to 20 variables, 20 equations, 10 user-defined functions, and 10 unit conversions.) The program's strongest technical feature is its nonlinear optimization.

TK Solver Plus 1.0, a $395 MS-DOS product from Universal Technical Systems, is a more sophisticated, open-ended product that can solve realistically sized models in engineering, finance, pure math, statistics, chemistry, and other mathematical fields. Some of its more interesting features are interactive display tables, user-defined procedures, input and output lists, list functions, a large-model capacity (>1000 equations, limited only by memory), and exceptional error-handling.

Eureka 1.0

Anyone familiar with Borland programming languages such as Turbo BASIC and Turbo Pascal will have an easy time learning Eureka; the pull-down menus, windowing controls, and editor are the same. Newcomers to Borland products shouldn't have much difficulty, either; the interface is simple and intuitive.

Instead of a programming-language source-code window, Eureka gives you an equation file window. The entire problem definition goes in that one window. ASCII-format equation files can also be loaded from and saved on disk. Other analogs to programming are the ability to set global parameters using commands in the equation file, and the ability to include other equation files implicitly with an `$INCLUDE` directive.

Copying the programming-language interface has its drawbacks, however. Most importantly, all the input values have to be provided in the program as equations or set as default values using a global switch setting. Also, you cannot easily obtain an orderly list of all variables in the model, one that clearly identifies the input and output variables.

To solve a set of equations, you exit from the edit window and activate the Solve command. Eureka first tries to obtain the solution directly, by reordering the equations and substituting constants. If the program makes six substitutions and still can't solve for all the unknowns, it begins an iterative process of making educated guesses.

After satisfying the equations, Eureka presents the results in a solution window. Each variable in the equation file is listed alongside its value. There is no indication as to which variables are constants and which were derived. After the variable list, Eureka gives additional information, such as the maximum error of the solution and warning messages.

Eureka has the very handy ability to constrain a solution. For instance, you may want to find a root of a previously defined function `f(x)` over a specified interval [−1,0]. You simply put the following into the solution file: `f(x)=0: -1 <= x <= 0`.

Equally powerful are the maximize and minimize directives. For instance, to find the maximum of `f(x)`, you use `$max(y)` and `y=f(x)`.

Eureka also plots functions that you define and presents a small text-mode graph. Pressing Alt-F5 generates a full-screen text-mode graph, and pressing F5 generates a graphics-mode graph (if a graphics adapter is installed). The text-mode graphs are surprisingly smooth, due to the clever use of three different characters for dots, effectively tripling the screen's vertical resolution.

Limitations of Eureka's graphing include the inability to plot more than one function on the same graph, and the absence of any grid marks or numbers except at the extreme points of the axes.

Eureka also has limited facilities for generating lists based on function evaluations. Given a function `f(x)`, the program generates a two-column table containing a list of values for `x` and `f(x)`. There is only one way to specify the values used for x: *start—increment—number of values*.

Eureka's reporting facilities are easy to use, but they are limited to the information developed in the screen windows. A pull-down menu lets you specify the output device (screen, printer, or disk file) for the report. The report contains the complete equation file, solution, and any graphs and lists that you generated. You cannot use it to generate more detailed tables or graphs. Additionally, you can set Eureka to keep a log file containing the results of various equation solutions.

Eureka has a context-sensitive on-line help utility. The help file is about 29K bytes of uncompressed text.

Eureka's 250-page user's manual gives a good operational view of the product. About 14 pages are devoted to modeling techniques—just a bare introduction to a very complex subject. The 100 pages of worked examples are very helpful. The worked examples are also included on the program disk.

TK Solver Plus 1.0

TK Solver Plus is a descendant of TK!Solver, introduced by Software Arts in 1983. Universal Technical Systems has

continued

George A. Stewart is a technical editor at BYTE. He can be contacted at One Phoenix Mill Lane, Peterborough, NH 03458.

Eureka version 1.0	TK Solver Plus version 1.0
Company Borland International Inc. 4585 Scotts Valley Dr. Scotts Valley, CA 95066 (408) 438-8400	**Company** Universal Technical Systems Inc. 1220 Rock St. Rockford, IL 61101 (815) 963-2220
Type Equation solver	**Type** Equation solver
Format One double-sided, double-density 5¼-inch floppy disk; not copy-protected	**Format** Six double-sided, double-density 5¼-inch floppy disks; not copy-protected
Computer MS-DOS-based computer with 384K bytes of RAM and one floppy disk drive	**Computer** MS-DOS-based computer with 384K bytes of RAM and one floppy disk drive
Documentation 250-page user's manual	**Documentation** 100-page tutorial; 200-page technical reference; 100-page application notes
Price $167	**Price** $395 for new users $145 with trade-in of TK!Solver 1.6 $200 with trade-in of earlier versions

rewritten the code in C to improve speed and portability (the original program was written in a proprietary development language of Software Arts). [Editor's note: *For a review of TK!Solver, see the December 1984 BYTE.*]

The user interface of TK Solver Plus is based on the concept of sheets of information that keep a model organized: There are separate sheets for rules (i.e., equations), variables, lists, user-defined functions, procedures, units, lists, plots, tables, numeric formats, and global settings. TK displays either one full-screen sheet or two split-screen sheets.

TK stores models in an abbreviated ASCII format. It can also read in and write out list data in WKS (used by Lotus 1-2-3), DIF (used by numerous spreadsheet programs), and ASCII formats.

You begin a new model by entering equations into the rule sheet. As each rule is entered, any new variables that you introduce appear in the variable sheet.

The variable sheet lists all the variables in the rule sheet. A status indicator identifies them as inputs or outputs and gives their most recent values. Variables can be either single-valued or associated with lists of values. List variables are used in TK's very powerful table- and plot-generation facilities. Variables can also be given the Guess attribute, which allows TK to use a specified first guess or the variable's most recent output value as a first approximation. Unless a variable has the Guess attribute, TK will not try to approximate it.

Each variable is associated with a subsheet giving additional properties of the variable: status, first-guess value, associated list, input or output value, numeric format, display unit, calculation unit, and comments.

If none of the unknowns has the Guess attribute, TK will attempt to solve the model using direct substitution methods. If not enough variables are known, TK will stop and tell you so. If there are conflicts between the equations, again, TK will stop and tell you. On the other hand, if you activate the iterative solver by assigning guesses to one or more variables, TK will go ahead and try.

Lists make it easy to generate and save a related set of calculations for use in further calculations or for generating tables or graphs. For instance, given the equation `payment = loan * (rate/(1-(1+rate)^-term))`, you can set up `payment` as an output list, `rate` as an input list, and all the other variables as input variables. Next, you can assign a list of 32 values to `rate`, ranging from, say, 8 to 16 percent. You can then specify constants for `term` and `loan`. TK will solve the equation once for each value from the `rate` list, saving the corresponding payment in the `payment` list.

Then you can generate a table or graph showing the payment required for various rates. Other list variables can also be included in the table. To specify the details of the table or graph, you go to the corresponding sheet and fill in information regarding format and content.

TK's interactive table subsheets (one for each table defined) let you modify the contents of a table cell and solve for the other related table entries. It's like using a spreadsheet, except that you haven't had to carefully plan the formulas that govern the row and column relationships.

TK has three kinds of user-defined functions: rule, list, and procedure functions. Rule functions serve much the same purpose as functions do in Eureka, except that they can be defined in terms of local variables that have no effect on the rest of the model; rule functions can also be defined in nonstandard fashion.

List functions relate two lists, a domain and a range, using any of four mapping techniques. Table mapping associates the *i*th element of one list with the *i*th element of the other list.

Step mapping uses the intervals between items in the domain list. Given an argument, a step function finds the first interval containing the argument and returns the value associated with the lower bound of that interval. Linear and cubic mappings also use the intervals between domain elements, but they interpolate values using linear or cubic polynomial approximation.

Procedure functions allow the specification of functions that are, in effect, algorithmic solutions. For instance, one procedure function might calculate the greatest common factor of two inputs.

TK's reporting capabilities are limited. You can copy the contents of most sheets to the printer or to a disk file, but you cannot generate a complete, readable report of the model, containing all the field definitions within each sheet.

TK's on-line help is context-sensitive and comprehensive. The help file is over 200K bytes of uncompressed text. TK comes with a 100-page tutorial manual, a 200-page technical reference manual, a 100-page application notes manual, the program disk, and additional disks containing a library of over 100 models and 200 procedures. All the manuals are well-written, and, taken together, they make TK a very well documented tool.

Technical Comparisons

The one area where Eureka may have an advantage over TK is in optimization of nonlinear equations. Using Eureka, it is very simple to locate the roots of nonlinear functions, to find a minimum or maximum, or to satisfy other combinations of constraints. It is possible to do this with TK Solver Plus, but it's not quite so easy.

For instance, given a previously defined function `f(x)`, find the values of x that give the maximum values on the interval $[-\pi,0]$. In Eureka, you could use `$max(y) and y=f(x): -pi()<=x<=0`. You then activate the solver. If Eureka

continued

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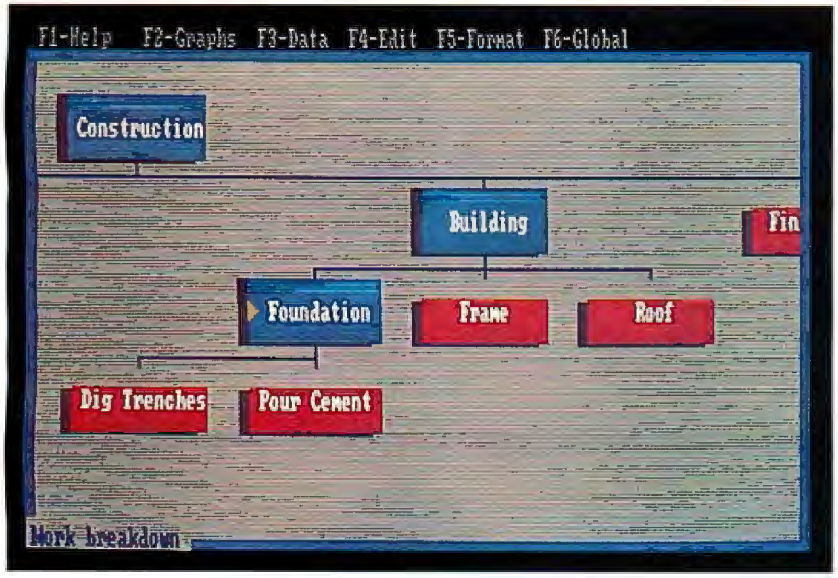

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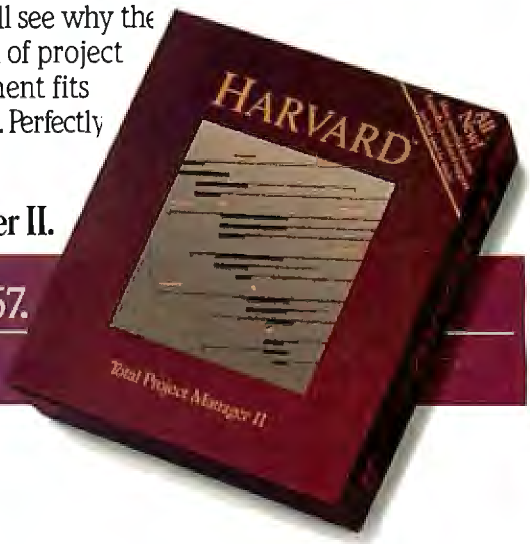

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finds a solution, you graph the function to see if other solutions exist on the interval. If they do, you adjust the constraint on x according to visual estimates from the graph.

In TK, after defining the function `f(x)`, you enter the rule `y = f(x)`. On the variable sheet, you make y an output-list variable and x an input-list variable. Fill the list x with, say, 50 values ranging from `-PI()` to 0, list-solve, and use TK's `MAX(y)` list function to find the largest value of y on the interval. You then input that value for y and back-solve for x. Even then, the maximum may not be exact: You've only broken down the interval into 50 subintervals. It might be better to now repeat the process over a smaller interval. Getting TK's best answer (maximum precision) takes some time. The proper way to solve this problem under TK is to use one of the optimizing procedures provided on the program disk.

Except for Eureka's built-in features for optimization and constraint problems, I found the two programs comparable in their iterative solving capabilities.

In some areas, TK is clearly superior. For instance, consider the following set of n simultaneous linear equations in $n+3$ variables:

$$a_1 = a_2 + a_3 - a_4$$
$$\ldots$$
$$a_n = a_{n+1} + a_{n+2} - a_{n+3}$$

I used these equations to test the solvers' back-solving capability by setting as inputs $a_1 = 1$, $a_2 = 2$, and $a_3 = 3$, and to test their reordering capacities by setting as inputs $a_{n+1} = n+1$, $a_{n+2} = n+2$, and $a_{n+3} = n+3$.

For $n=10$, Eureka took 72 seconds to back-solve. Setting the substitution level to 0 cut the solution time to 54 seconds. With the substitution level set back to 6, Eureka took 5 seconds to do the reordering test. TK took a split second to do both tests for $n=10$. (Tests were done on a 4.77-megahertz IBM PC with an Intel 8087 floating-point processor, which both packages fully support.) Eureka was unable to solve the equations by direct methods and had to resort to iterative methods.

In another test, I gave both solvers a set of eight linear equations in eight unknowns. Both solvers had to resort to iteration to produce a solution. TK took 6 seconds; Eureka took 77 seconds with substitution level 6, and 48 seconds with substitution level 0.

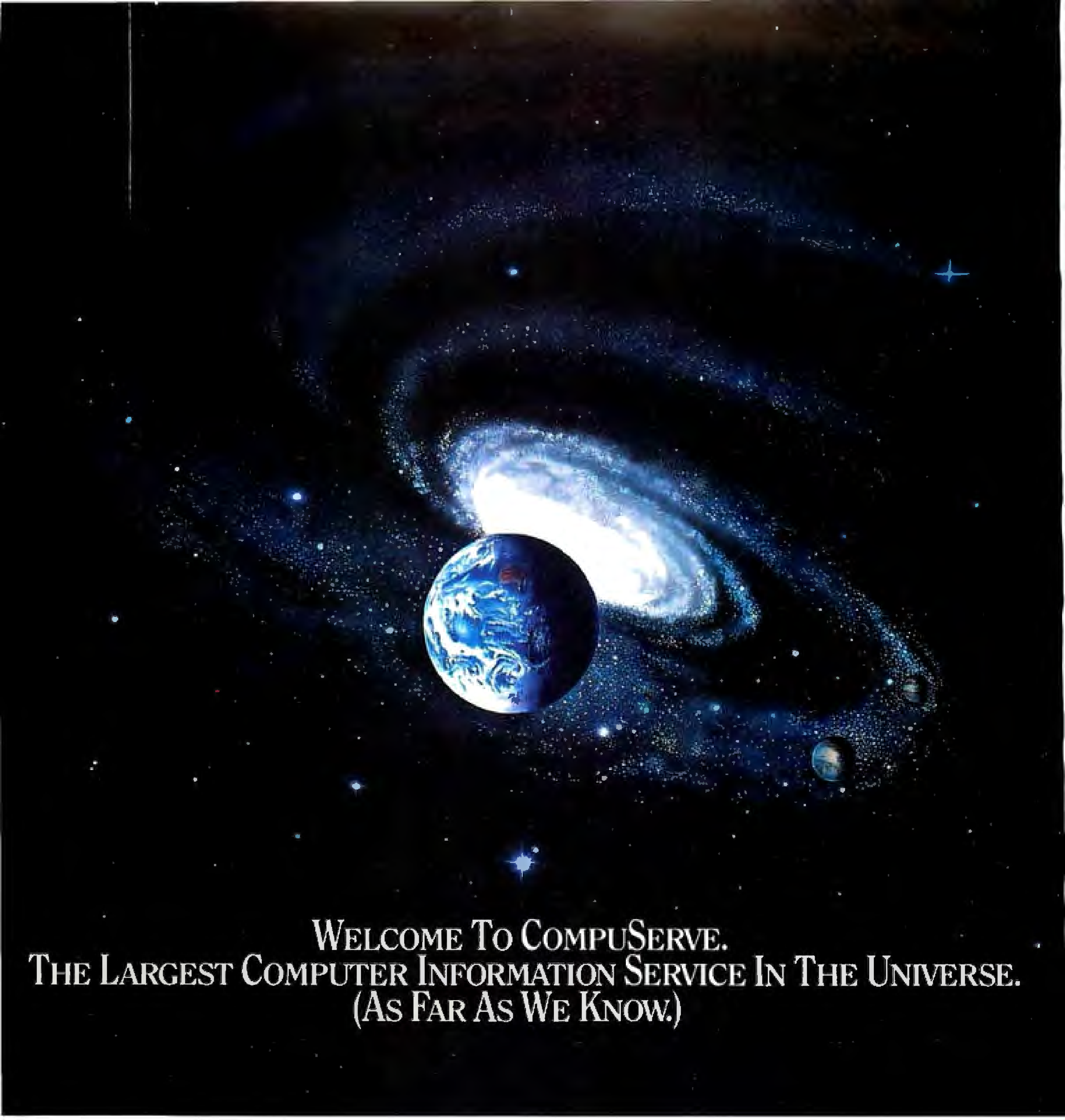
Automatic equation-solving is a deceptive area, and one must evaluate results carefully. Eureka is particularly liable to produce meaningless results. For instance, given the equation file `d=0: 8-b=8: 77/b=c/d`, Eureka came up with `b=0`, `d=0`, and `c=.99474364`. It also printed a warning that the solution process resulted in an attempted root or log of a negative number. This cryptic warning was not visible in the small solution window; I had to zoom to see it. Given the same set of equations, TK (correctly) refused to give any answer and printed an error message about division by 0.

The Real World

Most real-world mathematical models involve dozens of variables, functions, and equations. Eureka 1.0's stated limit of 20 variables, 10 user-defined functions, 20 equations, and so forth, makes it inapplicable to many real-world problems. On the other hand, the program is perfectly suitable for smaller, educational models, as evidenced in the sample models distributed with the program.

TK Solver Plus 1.0 is the obvious choice for someone who needs a mathematical tool for professional work in engineering, mathematics, finance, and other scientific fields. ■

continued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Personal Consultant Plus

Ernest R. Tello

Can a real expert system be developed and used on a personal computer? The experts at Texas Instruments think so, and they offer Personal Consultant Plus to prove their point.

Personal Consultant Plus version 2.0 ($2950) is a LISP-based expert-system shell written in PC Scheme LISP. It offers frame-based representation, forward and backward chaining, meta-knowledge control, graphics displays, and a broad interface to Scheme LISP.

Personal Consultant Plus (which I'll call PCPlus) includes a complete copy of PC Scheme LISP version 2.0, with full documentation. The program runs on the IBM PC AT and compatibles with at least 512K bytes of memory; 640K bytes is highly recommended. Versions are also available for the TI Professional and Business Pro.

The current version of PC Scheme supports the Lotus/Intel/Microsoft Expanded Memory Specification (EMS) and extended memory for the IBM PC AT and compatibles. [Editor's note: *For a review of PC Scheme LISP, see "PC Scheme: A Lexical LISP" by William G. Wong in the March BYTE.*] The PCPlus program itself comes on two disks, and it also includes a run-time disk, used for producing a stand-alone expert system. I tested PCPlus on a 10-megahertz IBM PC AT–type computer with 640K bytes of RAM, a 40-megabyte hard disk drive, and an EGA display.

The User Interface

PCPlus lets applications users ask the system why information is being requested, how a conclusion was arrived at, and what the user's responses were. The user interface also gives the user a way to avoid tedious repetition when a knowledge base is used frequently. With the SAVE PLAYBACK FILE command, if a user gives consistent answers up to a certain point in a knowledge base and gives differing responses from that point on, he or she can save the image of the session up to that point for reloading. Thus, instead of having to answer the same questions each time, the user can pick up a session at the point where it becomes significant.

Because the user interface for PCPlus is easy to understand and use, in the rest of this review I'll concentrate on the development environment in PCPlus.

The Development Environment

The PCPlus development environment is frame-oriented, with context-sensitive menus available through the F2 key. One of the more interesting development commands is TREE ON. When this is toggled on, PCPlus displays frames in the form of a tree diagram rather than as a simple list of names. PCPlus uses a frame representation to organize, in the form of parameters and rules, the knowledge contained in applications.

Each frame has a number of properties, which fall into two main groups. The first group consists of properties built into all frames, with values assigned by the developer. The second includes properties with default values that can be changed only after the frame is created.

When you're creating a new frame, PCPlus requests the three frame properties, GOALS, INITIALDATA, and TRANSLATION. The GOALS property is a list of the conclusions a frame must seek. The INITIALDATA property contains the names of the parameters to be requested from the user each time the inference engine considers the frame. The third frame property, TRANSLATION, contains textual descriptions of the frame, which are used to provide output in a more readable and understandable format.

A number of frame properties have default values. The DISPLAYRESULTS property has the values *yes* or *no* and, as the name suggests, determines whether the results of processing a frame should appear on the screen. The default value is *no*. The IDENTIFIER property names instances of a frame. The default is the name of the frame followed by a hyphen and the number of the instance. The PROMPTEVER property contains the textual message to be displayed each time a new frame instance is created. PROMPT1ST, on the other hand, contains a question that determines whether the subproblem of that frame will be considered. Similarly, PROMPT2ND asks a question that determines whether another instance of the frame will be entered.

In addition to these properties, a number of knowledge structures are usually associated with frames. Knowledge structures contain the list of parameters associated with a frame, control the number of times a given frame is instantiated, and list the meta-rules that govern the behavior of the frame.

Dividing a Knowledge Base

Subframes partition a knowledge base into a number of related subproblems. When the inference engine needs to test a rule in an uninstantiated subframe, it must first instantiate not only that frame, but any and all frames between it and the root frame, and it must satisfy all the goals of the intermediate frames before trying the rule it needs.

Developing efficient knowledge bases with PCPlus means taking careful control of the way frames are instantiated. PCPlus provides options in chaining, system functions, rule properties, and meta-rules that give the developer precise control of frame instantiation.

Control with Chains

In PCPlus, rules, like frames, have properties. The major property is that of being either a consequent or antecedent rule. This is established by setting the ANTECEDENT property to *yes* or by letting it default to *no*.

Consequent, or backward-chaining, rules are searched when frame goals are activated. While most common frame situations use consequent rules, antecedent rules have properties that make them indispensable in controlling the behavior of a knowledge base. One of the main uses of antecedent, or forward-chaining, rules is to propagate inferences forward, based on information the system has already determined, so that there will be no need to further query the user or try more rules.

Forward-chaining rules do not seek the necessary parameters for evaluating a rule, but instead can rely on values already known to the system to prove a rule. No matter how many times an antecedent rule fails, it may still fire at a later point when the needed information becomes available. However, once a antecedent rule fires, it is never evaluated again.

A rule may also have the property of being self-referencing. A self-referencing rule, which can be either forward- or backward-chaining, references the same parameter in both the IF and THEN clauses. One of its uses is to provide a default value to a parameter whose value the system has been unable to determine. So, for example, the rule

```
IF:    BUSINESS-TYPE =
       SOLE-PROPRIETOR AND
       NUMBER-EMPLOYEES = UNKNOWN
THEN: NUMBER-EMPLOYEES = 1
ANTECEDENT: YES
```

assumes, unless told otherwise, that a sole proprietorship has one employee.

Control with Rules

System functions are used in rules that make up knowledge bases. They are applied in both the IF and THEN sections of rules to state relationships between facts.

IF expressions of rules use predicate functions, and THEN expressions use conclusion functions. Text and arithmetic functions act on the data that their names suggest. Auxiliary functions are used in IF and THEN statements that provide assistance in the evaluation of parameter values. The functions in the auxiliary category are generally used in more complex knowledge bases dealing with less common areas of information.

The DOBEFORE and UTILITY rule properties capture knowledge about application-level control. The UTILITY property of a rule measures how useful or important the rule is in determining the value of a goal parameter. The inference engine tries rules with the highest UTILITY value first; rules with a negative UTILITY parameter are not tried at all. The UTILITY property permits control of the order of rule-processing without the need for meta-rules. However, for more precise control, you can write meta-rules that fine-tune the higher level control by modifying the value of the UTILITY parameter, depending on the behavior of the rules.

Meta-rules modify the list of rules to be processed to make knowledge-processing more focused and efficient for the problem at hand. They do this by eliminating rules from the list altogether and by reordering them into a more propitious sequence. In PCPlus, mapping functions are often used as tools within meta-rules. These functions access and evaluate rules, frames, and parameters, and map the elements meeting certain criteria into a list.

Linking to a Database

You can use PCPlus with existing databases created by dBASE II, dBASE III, and dBASE III Plus. For this purpose, PCPlus provides several functions that let you use a knowledge system as either a front end (gathering and maintaining information) or a back end (accessing information) to the database, or as both.

An important limitation of the dBASE functions in PCPlus is that they recognize only numeric and character data types; they do not recognize the data, logical, and memo data types. When you use a system as a front end, you can update dBASE data files by including the appropriate dBASE function in the THEN clause of a rule. For this to work, you must install the dBASE program in the same directory as PCPlus.

Personal Consultant Plus version 2.0

Type
Frame-based expert-system shell

Company
Texas Instruments
Data Systems Group
P.O. Box 2909
Austin, TX 78769-2090
(800) 527-3500

Format
Three 5¼-inch floppy disks

Computer
IBM PC AT and compatibles, TI Professional, or TI Business Pro with at least 512K bytes of memory (640K bytes recommended) and MS-DOS 3.1 or higher

Language
PC Scheme LISP

Documentation
388-page *PCPlus User's Guide and Reference Guide* (two volumes)

Price
$2950

A Picture of Knowledge

PCPlus has broad support for using high-resolution (including EGA) graphics with expert-system applications in a variety of ways, for both IBM and TI computers. The SNAPSHOT utility is a program that lets you capture graphics screens in a compressed file format, for use with knowledge-system applications. You can incorporate graphics screens into Help facilities, use them as prompts when a knowledge system needs to get some critical information from a user, and use them to display information that accompanies the conclusion of a knowledge-processing session. For example, in an expert system for diagnosing difficulties with technical equipment, detailed labeled diagrams of different views and states of the apparatus can be provided.

Integrating with PC Scheme LISP

One of the most important features of PCPlus for LISP programmers is its open architecture. You can use PC Scheme

continued

LISP functions to customize knowledge bases, and PCPlus allows two different forms for writing the entire knowledge base: You can write it either in the ARL (augmented rule language) syntax that PCPlus uses, or in Scheme LISP syntax.

Most of the frame and rule properties in PCPlus can be defined with custom LISP functions coded in PC Scheme. For example, the EXPECT property can access a LISP function that returns a list of the possible values a parameter can assume. In addition, a mechanism is provided that lets you include custom LISP code when you first load PCPlus. Such customization can range from resetting default values in the PCPlus environment to adding new functions.

A Stand-Alone Expert

PCPlus comes with a special run-time disk. Run-time versions of applications are prepared with the BUILD command. The disk is copy-protected, so any additional run-time disks have to be purchased from Texas Instruments; they cost $95 each, or 20 for $995. The code of the knowledge base packaged in a run-time system is protected so that it cannot be modified; furthermore, the run-time disk acts as a key disk and must be present even when the application is copied onto a hard disk. All in all, the run-time system provides the commercial developer with an easy-to-use system that protects the integrity of the knowledge base and the programming.

An Expert on Your Desk

PCPlus is a full-featured development and delivery environment for PC expert systems. The prime characteristic that distinguishes PCPlus from other shells is its total reliance on the frame as a representation of knowledge. Other systems may provide the developer and user with the option of organizing a knowledge base into frames; PCPlus forces organization of knowledge into at least one frame.

A major limitation of PCPlus, however, is that it does not provide a standard way to change the method of calculating certainty factors. This is an important issue for certain problem-solving strategies. In PCPlus, for a rule to have a value of *true,* all the premises in the rule must test true. But there are cases in which it is desirable for a rule to succeed if a certain percentage or combination of premises is true. It might be possible to overcome this limitation by using the interface to Scheme LISP; but this would not be a trivial undertaking, and the programmer would have to provide complete documentation of the necessary aspects of the implementation.

For those adept at LISP programming, the best feature of PCPlus is undoubtedly its open architecture, which lets you fully integrate programs in PC Scheme with PCPlus applications. PCPlus has great potential as an intelligent front end to a complex knowledge base. With the object-oriented SCOOPS extension to PC Scheme and its other powerful features, like environments, engines, and continuations, some very powerful applications are conceivable, which would owe no apologies to AI systems running on far more expensive hardware. ■

Ernest R. Tello (1518 West Cliff Dr., Santa Cruz, CA 95060) is director of research and development at Integral Systems. He is the author of the upcoming Mastering AI Tools and Techniques.

Guide

William Hershey

In 1965, Ted Nelson proposed hypertext, a way to link interrelated information so computer users could jump from topic to topic, find related subject areas, and generally extract only what they needed from large quantities of information. Guide 1.0 from OWL International attempts to bring this concept to the Macintosh. At $134.95, Guide is an affordable introduction to the subject. [Editor's note: *OWL recently announced an IBM PC version of Guide for $199.*]

What Is Hypertext?

Word processors present information in a straightforward, linear fashion: You read the first paragraph, then the second, and so on. Outline processors let you create documents with details that are hidden in a hierarchical tree structure.

Hypertext takes the next step, creating complex networks of information linked by pointers and cross-references. With a true hypertext system, you can read an entry, jump automatically to other related entries, find cross-references to these entries, and easily jump back to the first entry. A true hypertext system provides links between text, graphics, audio, video—any kind of information that a computer can digitize and access.

While limited to text and graphics, Guide lets you create hypertext-type documents on a Macintosh with 512K bytes of memory. The main Guide program lets you create Guide documents (called Guidelines), read them on the screen, save them as MacWrite documents, and (if you insist) print them. OWL also offers three read-only methods for Guidelines (one is included; two are optional), each with a different objective.

Reading a Guideline

A Guideline can be a mixture of text and graphics, much like a MacWrite document. But certain words, phrases, or graphic objects can be "buttons" that provide links to hidden text and graphics. Text buttons may appear in any style, but they typically have distinctive attributes, like boldface or italics, to distinguish them from the rest of the text.

Boldface text, for example, indicates a *replacement* button. Clicking on this button reveals hidden replacement text or graphics that are inserted after the button or displayed on top of it; it's similar to expanding a heading in an outline processor to reveal more details.

Underlined text indicates a *note* button. When you click on one of these, a pop-up text/graphics definition of the item appears in a window at the upper-right corner of the screen. It remains on the screen as long as you hold down the mouse button.

The use of italics indicates a *reference* button, which opens up a new window to show a different Guideline document (at a specific reference point within that document) or branches to a different part of the Guideline containing the reference button.

When you click a button and Guide displays the appropriate replacement or reference, you may encounter more buttons that will take you elsewhere. But you may wish to return to the place in the Guideline where you clicked the button. You can make a replacement disappear by placing the pointer over it and clicking the mouse. If a reference button has moved you to a new window for the referenced material, you can return to the original Guideline by clicking on a backtrack symbol that appears at the top of the window's vertical scroll bar. Guide keeps track of up to 32 cross-references, so you can backtrack from deep within a tree of references.

However, if you open up several cross-reference windows, keeping track of where you are can be a problem, especially with a poorly designed set of Guidelines. I'd like Guide to have a pull-down menu listing the open document windows, as MORE and Excel do, to supplement the backtrack feature for finding the right windows. Although you can size and move the windows and make any window active by clicking on it, this type of exploration can be cumbersome.

Writing a Guideline

Writing a Guideline is somewhat more difficult than reading one. This is due partly to the program's flexibility, and partly to some quirks in the user interface. If you know how to use MacWrite, entering text is easy enough; the tricky part is dealing with the buttons.

While the interface is 100 percent Macintosh, the Make menu can cause confusion. Make has nine menu choices for making buttons, plus a `Set Attributes` item that affects the attributes of individual buttons as well as of defaults. One entry in the Make menu, `Inquiry`, is a misnomer that performs two very different functions: bracketing groups of replacement or reference buttons that are to be mutually exclusive, so that clicking one button hides the others as the replacement or reference appears; and bracketing text for styling or font changes. In addition, creating a link between a note and its definition differs, depending on whether you are using the definition once or more than once. The Make menu needs simplification, to clean up the terminology and make the manner of creating the three basic button types more obvious.

Another problem with Guide is the lack of an `Unmake` command for replacement buttons. The `Undo` command (found, as with most Macintosh applications, under the Edit menu) will unmake a button you've just made; but if you change your mind about a button later, you have to cut and paste the button and its replacement separately to another part of the Guideline if you want to salvage them.

Guide Graphics

Although you can't create graphics with Guide, you can cut and paste MacDraw or MacPaint images into a Guideline. When you select a graphics image in Guide, the object will have MacDraw-like handles that you can use for stretching and shrinking. Also, if you make a

continued

Guide version 1.0

Type
Hypertext document-creation program

Company
OWL International Inc.
14218 Northeast 21st St.
Bellevue, WA 98007
(206) 747-3203

Format
Two 5¼-inch floppy disks; also available on two 400K-byte 3½-inch floppy disks; not copy-protected

Computer
Apple Macintosh with at least 512K bytes of memory; mouse required

Documentation
198-page reference manual; numerous files containing sample, tutorial, and help Guidelines

Price
Guide (including MiniGuide): $134.95
Guide Envelope: $199.95
Guidance (including Guide): $500;
with distribution license for Guidance applications: $2500

guideline's window narrower, Guide not only reformats the text to the new boundary, but scales down the graphics as well. You can also drag graphics objects and use Guide's `Pull to Front` and `Push to Back` commands to rearrange them.

You can make any graphics object into a button, which means that you can link various parts of a picture to textual descriptions of the parts or to exploded pictures that show more detail.

Creating Stand-Alone Guidelines

Guide comes with a MiniGuide desk accessory that lets you read (but not write) Guidelines from within other applications. Unfortunately, OWL does not give you permission to distribute MiniGuide to anyone else.

The Guide Envelope system, available separately for $199.95, lets you convert Guidelines to stand-alone applications, called Envelopes, which you can copy and distribute to as many people as you want. The system is also read-only; you still need to have the Guide program to create the Guidelines. The Envelopes that you create look just like the original Guidelines, except that you cannot change them; both MiniGuide and the Envelope system have a `Find` command, but they lack the main Guide program's `Change` command. Both MiniGuide and Guide Envelopes let you copy material from Guidelines to the Macintosh Clipboard.

The third read-only package is called Guidance, a $2500 package designed to replace printed documentation manuals with interactive, on-line, hypertext documentation. Like MiniGuide and the Guide Envelope system, Guidance is based on Guidelines, which developers can incorporate into applications as desk accessories with context-sensitivity. This type of on-line help system is an application for which Guide is perfectly suited.

A Worthwhile Introduction

Guide's innovative capabilities easily outweigh the current minor flaws in its user interface. The product points the way to future "hypermedia" systems that will link animated video and sound with massive text and graphics files. For now, Guide is an affordable, highly functional program that will let you dabble in hypertext—and maybe get your points across more effectively. ■

William Hershey (The MITRE Corporation, 1820 Dolley Madison Blvd., McLean, VA 22102) is a systems engineer and an instructor in computer applications at the University of Maryland's University College.

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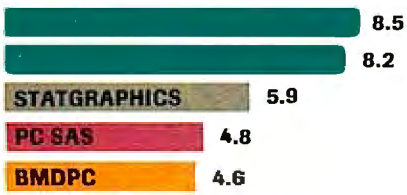
In doing so, they aren't alone. Every published independent comparative review rates Systat at the top of the list.



Of the statistics packages reviewed by InfoWorld, *Systat rated highest, as it has in every published competitive review.*

Some practical benefits.

Such ratings are important because they relate directly to the quality of your work, not just to glitzy features. For example:

Are capabilities important to you? Systat gives you more statistical capabilities than any microcomputer statistical package, including three major procedures that PC SAS® and SPSS/PC+® programs simply don't offer.

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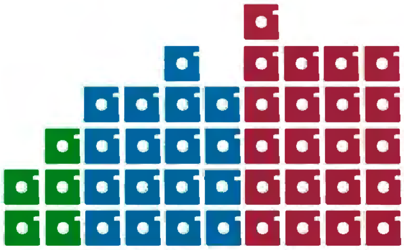

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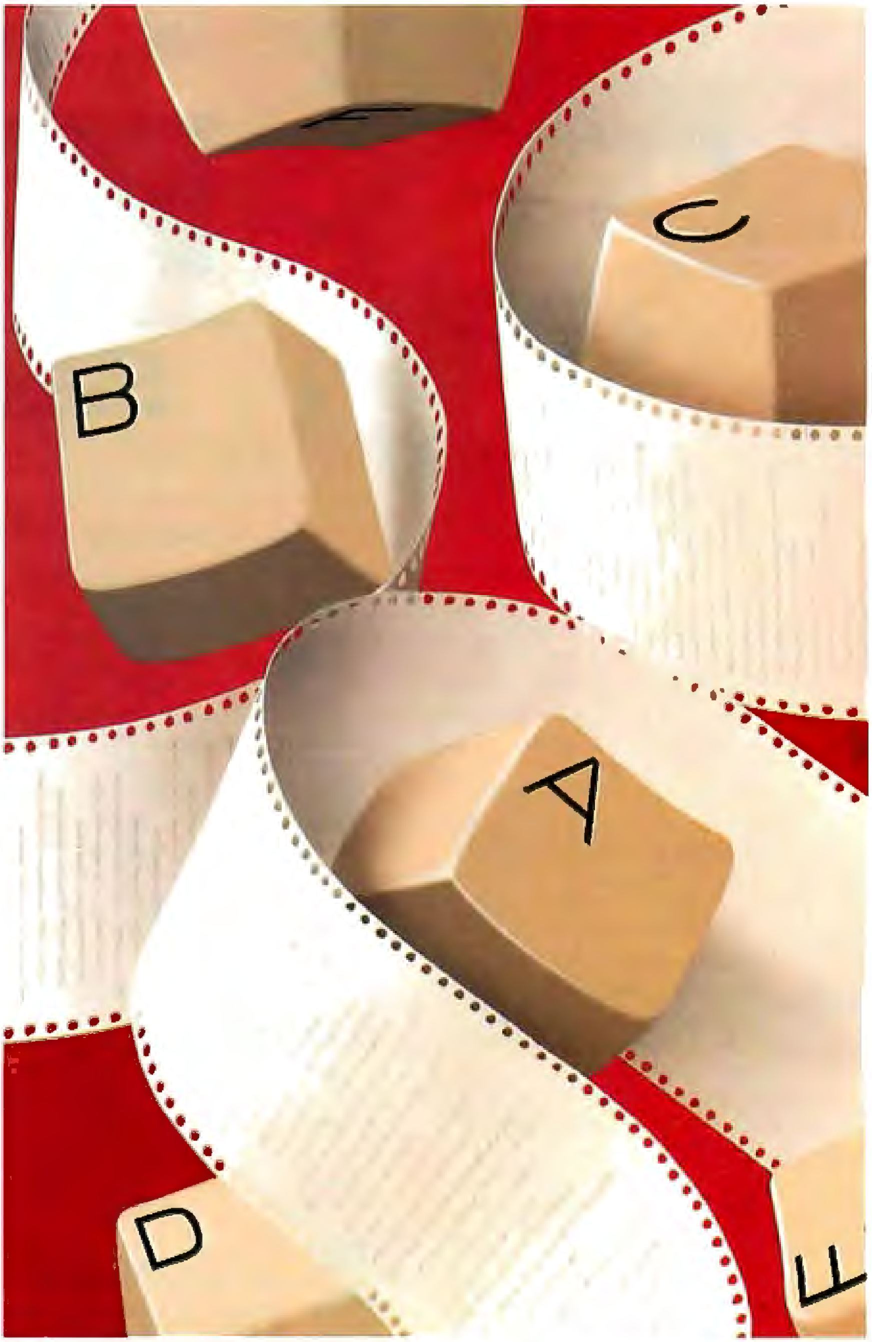
Kernel



New Life for Lucy

Jerry Pournelle

Jerry's genuine, original IBM PC receives a new lease on life

It doesn't seem like a month since the last column, and now that I think of it, it hasn't been. Westercon, the Western Regional Science Fiction Convention, is next weekend, so I'm doing this almost a week early. Last month, I was more than a week late, so this "month" has only had two weeks in it. Larry Niven and I have been hard at work three days a week on *The Moat Around Murcheson's Eye*, using up even more time. Oh, well. There's plenty to write about.

Pumping Up Lucy

It all started with the Sota Technology MotherCard 5.0. This is a board you can drop into an ordinary IBM PC to turn it into an AT compatible. After you put in the board, you remove the 8088 from the PC's motherboard and run a cable to it. The result is said to be much better than an accelerator board, because it's 100 percent AT-compatible, and it will run 80286 protected-mode software (assuming that any gets written).

I'd heard good things about the Sota MotherCard, and when one arrived it seemed like a good thing to install in Lucy Van Pelt, our original IBM PC. Of course, if we were going to upgrade Lucy, we figured we might as well go all the way and install a hard disk.

Lucy has always had a sort of hard disk: a 500K-byte bubble-memory board from Helix Systems & Development. There was a time when I was sure that bubble memory was going to replace spinning metal for mass storage. Bubbles are faster than hard disks and totally nonvolatile; you can pull the Helix card out of one machine and drop it into another with all the files intact. Bubbles are also a great deal more rugged than hard disks. They can take higher temperatures and don't generate much heat, and they'll take as much mechanical impact as any other board will take, so that your "hard disk" is no longer the most fragile part of the system.

Alas, Intel never managed to make bubble-memory chips small enough or cheap enough to be a serious contender, while hard disks just kept getting cheaper and cheaper. Our Helix card has operated flawlessly for years, but it holds only half a megabyte, and that's just not enough. I'll keep it for when I put together a rugged portable PC, but it was long past time to give Lucy 20 megabytes.

The Sota MotherCard would work with Lucy's old 75-watt power supply, but a hard disk would need more; time to replace the power supply, too.

First Try

Someone, I don't recall who, had recommended a company called Unitex in Silicon Valley. I called and ordered a 150-W power supply ($55) and a 20-megabyte hard disk kit ($375). The package came just before we went off to COMDEX. When I got back, it took about half an hour to install the new power supply: no directions needed, just be logical. You can't get the power plugs in wrong. Lucy ran fine as soon as I turned the power on.

Then came the hard disk. Alas, neither disk nor controller had any instructions or documents whatever, other than a printout that listed the (few) bad sectors on the hard disk. I removed the Helix bubble-memory card and the B: floppy disk drive and installed the hard disk and controller. There was only one way to put in the cables.

The disk powered up—and was *very* noisy. The computer booted from the floppy—and insisted there was no hard disk installed. The controller has several jumper sets, but I haven't the foggiest notion of what they do. My son Alex took the disk off and tried it on a later-model PC, and it appeared to work; but when we brought it back here, nothing.

One thing I might have tried, but didn't, is the SpeedStor hard disk utility (see last month's column); but we'd spent a lot of time on this, and the thing was so noisy I wasn't too happy with it anyway. One of these days, I suppose I'll send it back. They've no business selling "kits" with no documents. Back in went the Helix bubble-memory card.

Priority One

About then I saw a flier for a blowout sale by Priority One. I've been buying equipment from that company for years, and one day on the way to the Burbank Airport, I noticed a Priority One showroom on Hollywood Way. Among the items advertised was the Gold Card 21, a 20-megabyte hard disk and controller on a card. The price was ridiculously low, I'd just got in some royalty checks, and it really was time for us to upgrade Lucy Van Pelt.

They also had a great price on the AST-2000 hard disk drive for the Macintosh Plus, big discounts on 3½-inch floppies, surge-suppressor boxes for about 30 percent of list price, and a bunch of other stuff I'd been putting off getting. To top it off, we were going out that way anyway, to a nursery to replace a dead azalea.

I sometimes think I'd be better off sticking to mail order. When I get to a sale at a computer store, it's hard to know when to stop. Anyway, about two hours and a thousand dollars later, we were back with a fuchsia to replace the azalea and a trunk full of computer hardware.

Gold Card 21

I have a lousy memory, and it doesn't seem to be getting any better. It used to be

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.

I could take comfort in having a better memory than my partner Larry Niven, but even that's getting doubtful.

What I kept forgetting was just how few slots there are in an original IBM PC—and how closely crowded they are. The result was a nasty surprise when I opened the machine to install the Gold Card 21.

Lucy Van Pelt was full up. Of course, I'd intended to remove the Helix board; but that wasn't going to be good enough, because while the Gold Card 21 needs *only one* slot, it's wide enough that it must be next to either an empty slot or a half-length card. I didn't have any half-length cards in the machine.

Fortunately, that turned out to be no problem. The video card in Lucy was a vintage full-length Hercules monochrome graphics board. It had served us well and had never given a problem, but now I needed half a slot. I recently got a Paradise Systems Hi-Res Graphics Card. That's a half-length card that's advertised to be Hercules-compatible, and for extras it has color capability as well.

There was a mild moment of panic when I replaced the Hercules board with the Paradise board and got no output at all, but that was fixed by moving the big slide switch on the Paradise card from "Color" to "Mono." I then ran a few programs that require Hercules graphics, and they all worked. I can't say I've done extensive tests, but none of us can tell the difference between the Hercules and the Paradise boards.

That gave me an open half slot, which I could arrange to be next to the Gold Card 21. I put in the Gold Card. So far, I hadn't done more than glance at the instructions. They're written in Janglish or something like it; complete, understandable, but in what is most charitably described as awkward syntax. There's a picture showing where to look for switch blocks on your PC motherboard, but the only instruction is, "NOTE! Switch settings will be in your systems technical manual. Refer to it."

I didn't remember ever doing that, but presumably I had once referred to "it," since Lucy believed the Helix board was a superfast hard disk. I figured the heck with it and booted off the floppy. Voilà! `DIR C:` established that I indeed had a 21-megabyte hard disk already formatted.

The Gold Card 21 manual carefully explained that the disk was already set up to use DOS 2.0 or 2.1, but if you wanted to boot up anything else, you'd have to reformat the disk using the DOS utility FDISK. I'd never used that before, but the manual made it sound simple, so I tried it. Amazingly, it *was* simple. Everything worked the way the Gold Card manual said it would.

After that, Lucy would boot DOS 3.2 off the hard disk. So far, so good.

AST SixPakPremium

Over the years, Lucy has had just about every kind of speedup board. For a long while, we used an Orchid PCturbo 186, which worked quite well. I forget why we took it out, probably to make room for something else, given the PC's limited number of slots. I certainly don't recall any problems with the Orchid board.

One board that stayed in was an STB Systems' Rio Plus board we originally bought from Priority One in the summer of 1984 for the Zenith Z-150. We had problems with it for the Z-150. Those were the days when you bought an IBM PC with 64K or 256K bytes of memory and then added 64K-byte chunks of memory (up to 384K bytes) with an add-on like the Rio Plus.

The Z-150 came with a capability of 320K bytes on the motherboard, and unless you'd filled all those sockets with memory chips, the Rio Plus couldn't add its memory to the system. The Z-150 also came with two installed serial ports. Alas, the Rio Plus has a serial port that must be addressed as either 1 or 2 (it wasn't possible to make it 3 or 4), which meant that it clashed with the Z-150. You could get a PAL that would disable the Rio Plus's serial port, but that seemed a waste, so we installed something else in the Z-150 and put the Rio Plus in the PC.

The Rio Plus could, in fact, bring the PC up to 640K bytes of memory, but there are other ways to do that; mostly, it served as a clock. Then in one DOS change or another we lost the BASIC program that set the Rio Plus's clock. Maybe you just need to use BASIC and `TIME$`; I'd forgotten, and we'd lost the Rio Plus's manuals. Anyway, by now the only real purpose the Rio Plus board served was for the serial and parallel ports. It did look as if it could go.

The obvious choice for a replacement was the Sota MotherCard that started the upgrade in the first place. It even has a built-in battery-backed clock. The only problem was that it was getting late, and I wanted to install and test a bunch of stuff on the new Gold Card disk—but not with an unfamiliar speedup card. We normally use the PC as the Q&A data-entry machine to log in the hardware and software that threatens to engulf us in a flood; time enough to put in the MotherCard after a couple of weeks of testing the Gold Card.

There were a bunch of other candidates, but the one on top was the AST SixPakPremium, which offers two serial ports, a parallel port, expanded memory, a clock, and suchlike, and it even offers DESQview if I want it.

Installing that took about 5 minutes: put the card in the machine, turn the machine on, and invoke the installation program that comes with the SixPakPremium. The manuals explain what's going on, and there are no really difficult choices.

The result is that we now have an IBM PC with quite a fast (15-millisecond track-to-track) hard disk, a 512K-byte RAM disk, a megabyte of expanded memory, a print spooler, and a real-time clock.

The CompuPro ARCNET PC board works fine with this arrangement. The network board takes up a full slot, of course, so the PC is full: floppy controller, hard disk card, AST SixPakPremium, Paradise Hi-Res Graphics Card, and network board. I have a bunch of cards that are said to speed up a PC, including the Orchid TurboEGA that not only speeds up the machine but gives it EGA capability as well. The TurboEGA will fit in the video board slot, only it can't in this case since it's a full-length board, and there'd be no room for the Gold Card. Sigh.

I'll try a bunch of accelerators and suchlike over the next couple of weeks. From the specs, the MotherCard still sounds like the best of the lot, but we'll see.

AST-2000

We also picked up the AST-2000 SCSI hard disk drive for the Macintosh Plus. The box pictures a unit with a tape backup and says prominently: "AST-2000 High performance, hard disk SCSI subsystem for the Macintosh Plus and the Apple IIe. Featuring 20 megabyte disk capacity with 20 megabyte cartridge tape drive." I figured that what I was getting was a disk with tape backup, and while I hadn't expected the tape backup, it was welcome; so I asked the manager what size tapes it took.

He didn't know, but he was sure they packed one in the box, so we opened it. Hah. Not only was there no tape, there was no tape drive. Eventually, we found a tiny sticker on the box that said "drive unit only." Since I hadn't really expected a tape drive unit at that price, I wasn't upset, but the box sure fooled everyone, including the store manager.

When I got it home, I found the drive packed in foam. A separate box contained cables, documents, and a 3½-inch disk of control programs. The documents talked of an "Apple SCSI Terminator" and pictured a large lumpy thing in the cable between the Mac and the drive. That scared me for a moment, since I was sure I didn't have a "Terminator"; but, in fact, that and everything else was packed neatly in the cable bag.

continued

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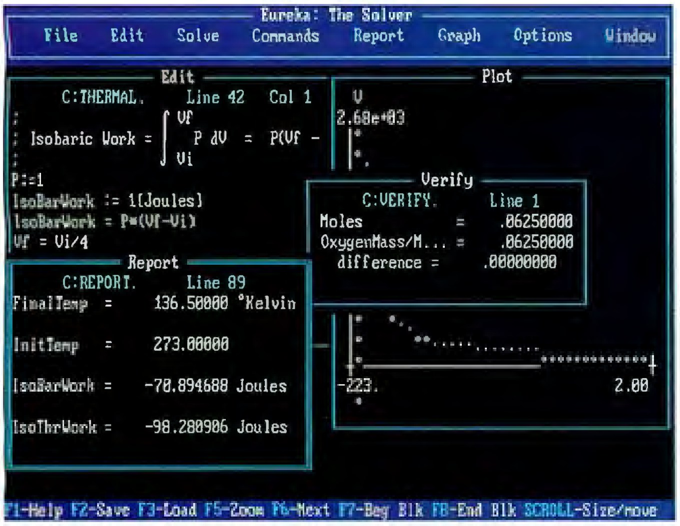

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BORLAND

The AST-2000 is a bit larger in footprint than the Mac, but it's a good height and fits reasonably well underneath the computer. Installing it took about 2 minutes, including installing the software. It really was as simple as the directions say.

The hard disk works fine, and it sure speeds up the Macintosh, particularly for games like Wizardry that need disk access while you're playing. Alas, I haven't found a way to put Strategic Conquest on the hard disk; that game doesn't do much disk access during the game, but it does take forever to get started. Oh, well. At least I can save games on the hard disk.

There's one disconcerting "feature" that I suppose can happen with any SCSI hard disk. If you have a floppy disk in the internal drive when you power up, the system boots up from the floppy, then tells you that the disk is unreadable. It wants permission to initialize it. The first time that came up, the floppy in question was Strategic Conquest, and I sure didn't want *that*, so I clicked on `Eject`. Nothing happened. I had to turn off the system to recover. I later learned that it's the *hard* disk that it wants to initialize, and, of course, it can't eject it.

There are two morals to this story. One, don't boot with a floppy in the system if you have a SCSI hard disk. Two, Apple should have put a control lever on the Mac so you can eject floppies without begging permission. Oh, well.

Another thing that has always galled me is that hard disks for the Mac cost about double what the same capacity costs for the PC. They're also very much larger than PC hard disks. Of course, if you want to get really unhappy, shop for hard disks for the Amiga.

System Saver Mac

Another gadget I bought at the sale was the System Saver Mac from Kensington Microware Ltd. This is a combination power conditioner, switching unit, auxiliary power outlet, and fan for the Macintosh. It sits on top in the "carrying handle" groove; you plug the Mac, hard disk drive, and whatever else you want to power up with the Mac into the System Saver Mac; there are two switches, so you can turn on the hard disk drive first, then the Mac.

I don't know what Apple has against fans. I'm told that Steve Jobs hated them, and although he wasn't in the habit of explaining himself, he once said that fans were noisy and drove away customers. It may be true, but the System Saver Mac's fan makes a nice little breeze, and even on a quiet night, it's not loud enough to bother me; in fact, it's not as loud as the AST-2000 hard disk drive, and that's very quiet.

I am also told by one of the original Macintosh development engineers that the designers were concerned about heat from the internal drive motor. My friend suggested that they extend the drive shaft and put a fan blade on the end. That way they'd get some air circulation during disk access, and it sure wouldn't add to the noise. When he told his idea to Jobs, the reply was an adamant "no," with no discussion. I suppose there are all kinds of management styles.

I don't know if the Macintosh Plus needs power conditioning and a fan, but the convenience of having multiple switched outlets was worth the sale price; and surely the fan can't hurt.

Mac II Blues

I'm told by reliable sources that the Mac II has a real problem: it strictly enforces the Mac programming standards. What makes that a problem is that much of the interesting Macintosh software was written by people who found the standard way of doing things far too slow and made "improvements."

Among these programs, they tell me, is Microsoft's Excel, which is the program Apple hopes will boost the Mac into a serious contender in the business world.

Incidentally, one of the best tests of Macintosh standards is, of all things, Dave Small's Magic Sac cartridge for the Atari ST. If software runs on a Magic Sac, it will run on the Mac, Mac II, and anything else that enforces those standards.

How to Bore Your Customers

One of the potentially best games I've received recently is Epyx's Sub Battle Simulator for the Macintosh. This thing is a lot of fun, or could be. The action is exciting, and the play levels are well-graduated so that you can start at a low level and work up. There are lots of missions, and you can even do a full World War II campaign (as either a U.S. or a German submarine commander).

There's only one problem. The game tries to be a simulation, and all too often it succeeds.

In one sense, it's not a very good simulation: your sub, on the surface at least, is just too powerful against aircraft. There are other things you can do in the game that would have been absurd in real combat. That, however, isn't the problem, because all those glitches make the game more exciting.

No, the difficulty is that for a great deal of the time in the real world, submarine duty is dull; and Epyx has simulated *that* all too well. If you play the game in real time, you will spend hours and days going from one place to another with literally nothing happening. Actually, lookouts can report "Smoke on the horizon" from ships up to 400 miles away, which is pretty good smoke, so that you will see more things than a real sub commander would; but nowhere near enough. Long trips are a crashing bore.

Epyx's remedy for that is a speedup: you can make a second of real time equal to 1, 5, or 30 seconds of game time; 10 minutes of game time; and 4 hours of game time. There is also a "navigator" function that you can invoke: put in latitude and longitude, and the program will "sail" you there.

Alas, neither of those works very well. If you use the navigator, about one time in six, you will find you have navigated onto a reef, or an island, or, in one case, about 50 miles inland; and when the game drops into real time, it instantly tells you that you've destroyed the sub. The time-speed thing isn't much better, and, again, it very often does you in just after you've completed several missions.

I suppose the game designers think of this as "realism"; you shouldn't be using the 4-hours/second capability unless you're very watchful. Whatever they think, I think it's boring to spend a lot of time going from one place to another.

Epyx isn't the only one with that problem. I have a (not yet released) Star Trek game for the Atari ST that has the greatest graphics I've ever seen, terrific action, a quest, and some interesting strategic puzzles; but, alas, you have to travel from one star system to another (on warp drive) and from one planet to another (on impulse drive, and in Hohman minimum-energy orbits yet; as if a starship couldn't move in hyperbolic orbits).

If you go at a high game speed, you will damage the ship. If you go at a more reasonable game speed, it takes a lot of *real time*, and, once again, you are sitting there waiting and waiting and waiting for something to happen, only in the game nothing *can* happen while you're moving from one place to another. I eventually

continued

gave up on the game because I got so bored with the time required to travel.

My son Phillip found that David Joyner's Faery Tale Adventure (game of the month last month) has much the same problem: eventually your character gets so powerful that no one can harm him, but he has to spend literally hours—in real time—going from one place to another. This gets dull fast.

The moral of this story is that if you're going to design simulation games, think of them as *games* as well as simulations.

Flash: I've just received a new copy of Sub Battle Simulator that fixes the navigator bug and adds some new features. This turns a boring simulation into an exciting game. I'm glad somebody listens.

Case Closed

Another thing we got at the Priority One sale was a ProModem 1200B/2 300-/1200-bit-per-second modem for Mrs. Pournelle's AT&T 6300 Plus. What happened was that I had put the half-card OmniTel 2400 modem in Fast Kat the Kaypro 386, and the old full-card OmniTel 300/1200-bps modem into her machine. I'd used that modem for two years with no problem, but lately it had started doing odd things, and the line noise was not too good. When we got it into the 6300 Plus, it got worse.

I'm sure OmniTel would have fixed it, or even replaced it with the half-card they ship now, but the Priority One sale price was good, and Roberta was eager to get working on the education conference she now moderates on BIX; so I bought the ProModem.

The ProModem comes with SoftKlone's Mirror communications program, which is pretty well a dead ringer for Crosstalk. Roberta was already using Crosstalk and had all her Crosstalk scripts and such set up; it seemed reasonable that all we'd have to do was set the ProModem to port 2 and turn things on. One day I ought to test Mirror, but Crosstalk ain't broke, so why fix it?

Anyway, it took about 3 minutes to install the modem.

Then it was time to close the AT&T 6300 Plus case.

I will never understand AT&T. They have some of the greatest development engineers and scientists in the world at Bell Labs, and their regular troops aren't too shabby either; yet with all that talent, they turn their computer design over to Olivetti. Not *all* the design, of course. The actual innards of the AT&T 6300 Plus was Project Safari at Bell Labs. That part works fine. The 6300 Plus is a good machine, with CGA better than most people's EGA, and it has lots of neat features. It remains Roberta's Attila the Honey, and she loves it. On the other hand, the case must have been designed by a demented tinker.

Now certainly the IBM PC case can be improved on. A number of clone makers have done just that and furnish a tilt-up case. On the other hand, the standard PC case is "good enough"; you take out a few screws, pull the case off, and that's that.

The 6300 Plus is different.

To remove the cover, you have to take out only two screws. Then you sort of jiggle and pull, and the case comes off easily enough, although it doesn't just pull straight back. When it comes to getting the 6300 Plus's cover on again, though, you have a fight on your hands. At least I did: it took me just about half an hour, at the end of which I was cursing the designer, his professors, his parents, and everyone else involved in that madman's birth and education.

I won't attempt to describe the latching system on the 6300 Plus. Suffice it to say that assembling children's toys of the "Insert tab A into slot B" variety on Christmas Eve is literally child's play compared to getting all four of the lid's oddly shaped tabs to lock simultaneously onto the case body. It can be done, but be prepared.

I don't know who designed that case, but I'd hate to think they'll let him work on anything else. In fairness, I should say that Paul Chisholm of AT&T says it takes him only 30 seconds to put the top on—and if I wanted a modem, why in heaven's name didn't I call AT&T?

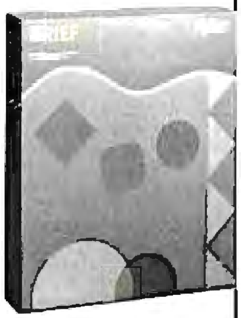
The ProModem works fine, though. Roberta didn't change her software at all, and now she's got a lot less line noise.

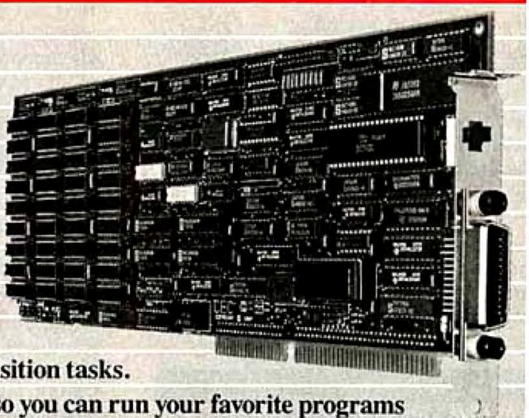
CompareRite

People are always looking me up at computer shows to tell me about a program that I simply must have. Most of the time I either already have a program to do whatever it is theirs does, or it's clear that the Inferno will run out of coal before I need *that* program; but sometimes I get a pleasant surprise.

CompareRite is one of the latter cases. It's an advanced program to compare two versions of a file and make a composite third version that has the original with the text deleted in the second version marked in one way and text inserted by the second

continued





version marked in another way. This makes it very easy to see what changes have been made.

CompareRite runs on a PC and works with most text editor formats. In my case, I use the CompuPro ARCNET PC board to transfer stuff from the ancient CP/M system I use for writing to the Kaypro 386 and do the comparisons there. It takes almost no time.

CompareRite is easy enough to learn and use. The menu system is a little tedious, but there's a command interface to shortcut it. The program is very speedy, and if you don't like the conventions it uses for marking insertions and deletions, there are options to let you change them.

If you write collaborations, it's obvious what you'd use this for. The manual has other suggestions. Editors can leave notes in text for authors; the notes will show up nicely. Merge versions of program documentation to make sure nothing is left out. Annotate stuff for yourself.

The program does *not* do something I badly want. I'd like to be able to open two versions of a file; have the program write to a third file everything that's common to both; and, where there are differences, show me in two windows the two versions, giving me a chance to choose the one that will be written to the output file. That way, I make a composite file of the best of both. So far as I know, though, there is no program that does that.

Otherwise, CompareRite does almost everything you'd expect a text comparison program to do. It's been added to my hard disk as a permanent working tool. Recommended.

The Write Dilemma

I'm still writing on Ezekial, the CompuPro CP/M Z80, but that can't last. There are just too many conveniences, like SideKick and Ready!, for PCs and PC-compatible machines. I already write just about everything but novels and BYTE columns on the PC anyway. Old machines were much slower than Zeke, but the Kaypro 386 may even be a bit faster; and the 19-inch Intecolor Megatrend EGA monitor gives me all the advantages of size, crisp text, and speed. In a word, it's a little silly to keep this enormous old Z80 "boat anchor" in addition to all my other equipment.

The only thing stopping me is that once I make a firm decision it will be nearly irrevocable, because my partner Larry Niven will then go out and buy an exact duplicate of my hardware and software. Actually, he'll buy *two* exact duplicates of my setup on the theory that the best maintenance policy is a second system.

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PROGRAMMER'S

Every time I'm about to choose a text editor, someone improves a rival.

He will then expect things to be stable for a few years.

The hardware isn't a real problem. Given that you can afford it, a 386 with a couple of megabytes of 32-bit memory, DataDesk's Turbo-101 keyboard, and the Megatrend monitor will be fast enough and good enough for some time to come, and there's already plenty of auxiliary software, with more being written every day.

The problem is the text editor. Writers spend more time with that than anything else; and every time I'm about to choose one, someone improves a rival.

I'd about decided on WordPerfect, when Symantec came out with Q&A Write. This is an enhanced stand-alone version of the editor that comes with the Q&A database. It's simple to learn and easy to use. There's a little card-file database and mail-merge capability, and it's easy to communicate with standard Q&A. Q&A Write comes with the Oasis spelling checker; I use the CP/M version of that now, and I like it. You get a coupon for a discount on the Microlytics Word Finder Thesaurus, and that's got 220,000 words and is about the best thesaurus program in existence—incredibly speedy.

There are a bunch of other features to Q&A Write, many of them added at my suggestion.

There are a couple of missing features I'd like, things like delete to end of line in addition to delete line; but Q&A Write has the WordStar delete commands, like Control-T for delete word, and even better, unlike WordStar, Q&A Write reformats the text automatically. I do wish they'd give me the option of eliminating the Tabset and Status lines; I don't like anything on the screen I didn't put there.

Meanwhile, there's WordPerfect, which is darned good and does have simple ways to delete chunks of text. I am still not happy with the way WordPerfect moves text, saves and deletes marked segments, and generally handles blocks of text. Q&A Write does that much better, or at least it looks that way to me. Still, WordPerfect is a good professional writer's tool, and they keep updating and adding features as I suggest them. If Symantec makes no more improvements, I'll stay with WordPerfect. Especially now that there's Mouse Perfect.

One complaint I've had about WordPerfect is that it doesn't recognize mice. Now true: the reason I don't like Microsoft Word is that the mouse is such an integral part of the program. When I'm creating text, I do *not* want to take my hands off the keyboard to delete words and lines by marking with mouse tracks (or arrow keys, for that matter). However, when I'm editing already-written stuff, I do like the convenience of using the mouse to get rapidly from one place to another, and mouse-driven menus can be useful.

Mouse Perfect adds that capability to WordPerfect.

When you use Mouse Perfect with WordPerfect, a click on the middle button of the Logitech LogiMouse (or on the Microsoft two-button job, both buttons at once) brings up a menu of things WordPerfect can do, like SAVE, SPELL, COPY, CUT, and DELETE. Clicking the mouse on one of those menu items either does the

continued

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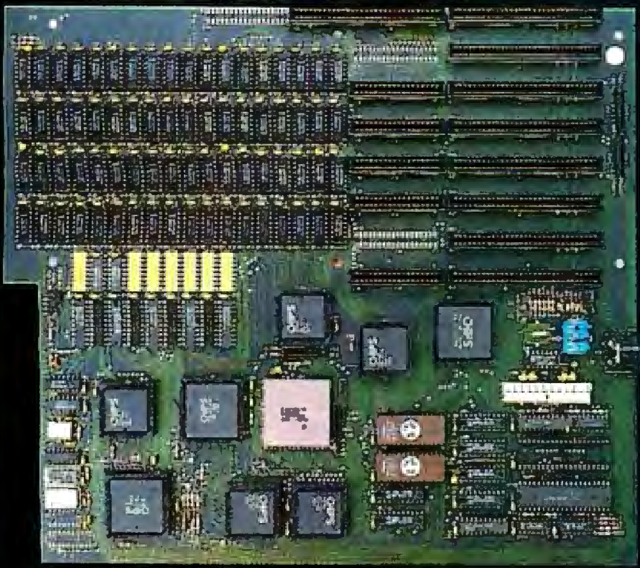

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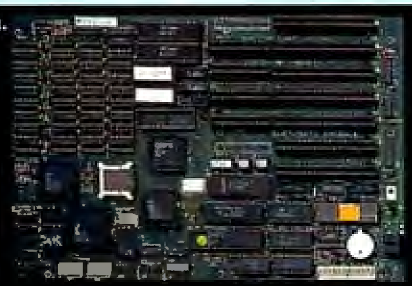

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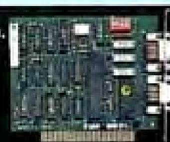

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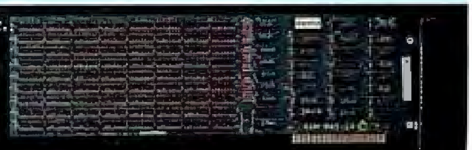

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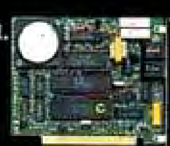

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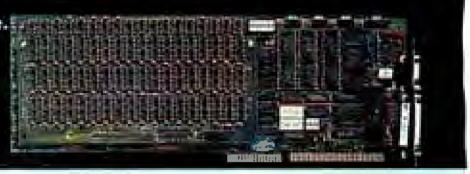

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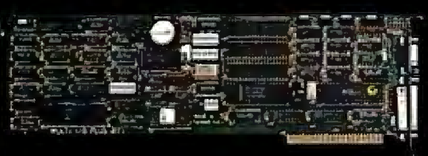

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command or gets you a new menu of options within that command. If you really know WordPerfect and can do finger exercises with Control-function keys and so forth, things may go faster if you don't use the mouse; but if you're still looking things up on the WordPerfect command list, the Mouse Perfect menu system is a lifesaver.

The menus are context-sensitive: there are about a dozen different command screens the mouse will show you, each appropriate to where you are within WordPerfect. The integration is very, very good.

Mouse Perfect won't work under DESQview. DESQview uses the mouse to create its own menu system; if you run the memory-resident Mouse Perfect in a batch file so that it's installed in the same window with DESQview, the result is to disable the mouse entirely; it won't work for *anything* until you kill that window.

The Mouse Perfect documents are terse, but written in English, and complete. It took me about 10 minutes to install Mouse Perfect and maybe another 10 in experiments to get comfortable with it. After that, I began to get dependent on it. I do wish it would run under DESQview, though. If you use WordPerfect and want a mouse, this is the program you need. Recommended.

I had literally just written the above when Dr. Gordon Eubanks, chairman of Symantec, stopped by to show me yet more features of Q&A Write. In particular, we looked into the different font cartridges I have for my Hewlett-Packard LaserJet Plus and noticed what's probably the best of the lot, the so-called Microsoft 1 92286Z. This has regular Courier; Times Roman 12-point in normal, bold, and italic; the same for Times Roman in 10-point type; a LinePrinter medium; and 8-point Times Roman medium; all in proportional spacing.

Q&A Write will support all of those, and we installed them; now I'm having fun playing about printing fancy manuscripts. I can certainly recommend that cartridge. Anyway, I showed Gordon the Mouse Perfect program. He ground his teeth and said they'd talk to the Mouse Perfect people about getting a version to work with Q&A Write or, barring that, implement something like it themselves. He also wrote down some other sugges-

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The potential of C is so humongous that Microsoft and Borland have about declared war with C as a battlefield.

tions, like having Q&A Write count words, lines, and paragraphs automatically the way WRITE does.

I still haven't chosen a text-editing program, but I love it when a plan comes together.

The Great C Compiler War

I confess I never thought there'd be a big market for C compilers.

C is a language about half a step up from assembly language. It's possible to write structured comprehensible code in C, although I've seen little of it; it's also possible to write incomprehensible routines filled with strange tricks.

C has a large number of good points for those who spend a lot of time writing C code; but for part-time programmers like me, it's not the language of choice because it's very easy to forget how you did something in C, even if you thought you'd written plenty of comments. I feel particularly sorry for software publishing outfits if they lose the original programmer and have to bring in someone else to maintain C code.

Of course, C is *the* Unix wizard's tool, and it has got to the point where knowing C is often thought to divide the real hackers from the hangers-on. Even so, I'd never in a million years have suspected anyone could sell a hundred thousand copies of the language.

Apparently, though, the potential of C is so humongous that Microsoft and Borland have about declared war with C as one of the battlefields. (Compiled BASIC is another; this morning, I received version 4.0 of Microsoft QuickBASIC.)

Both would as soon ignore Lattice, which isn't as big as Microsoft or Borland but still has plenty of loyal supporters. Those are, though, the "Big Three" companies making C compilers for microcomputers.

Although I'm no C hacker, all three companies keep soliciting my opinion, and so have a lot of readers. Fair warning: this is an outsider's view. I've talked to a lot of people, users and compiler writers, and this is what I've come up with.

Turbo C from Borland is faster than the dickens, writes neat code, and is one heck of a bargain at a price of $99.95. Anyone who has the slightest interest in learning C, or even in learning a good bit *about* C, will want the Borland package; at that price, you can't afford not to have it. It's the clear choice for beginners and dilettantes.

The Borland integrated editor/environment looks and works pretty much like the Turbo Pascal environment, and it's plenty easy to learn. The Borland compiler looks and feels a lot like the long-known Wizard Compiler, and although Borland says they only bought Wizard talent, most hackers think there's a great deal of the Wizard in Turbo C; and since the Wizard Compiler always was a nice compiler, this is no bad thing.

Whatever your interest in C, if it's at all serious, you're likely to want to get Turbo C.

On the other hand, Microsoft C has Codeview, which is arguably the best debugger in microland. If you do much C hacking, it's worth having Microsoft C just to get the debugger. On the other hand, the Microsoft libraries were developed with one eye on Xenix, and Microsoft will never release the source code to those libraries.

Now comes Lattice. Lattice has libraries more in tune with MS-DOS; and you can get the library source code. Experienced C hackers tell me that for really humongous programs, the Lattice code is a bit more elegant; one even used the phrase "more stable" while hastening to add that he wasn't implying there were serious defects to the Microsoft code. Lattice doesn't have an integrated editor environment like Borland's, but then most hackers use command line anyway.

Microsoft has cross compilers for their C, but they don't necessarily release them; Lattice does.

So far, the conclusion seems to be that the Borland compiler is a great bargain for professionals and amateurs alike; but for big, hairy C jobs, the contest is between Microsoft and Lattice, and many programmers use both, switching back and forth as they need the Codeview debugger.

Comes now the dark horse. In addition to the Big Three, there's MetaWare's High C. This is a fairly expensive compiler that's enthusiastically recommended by some of the best known names in the industry, including Gordon Eubanks. There's no debugger for it; Eubanks uses the Phoenix PFIX and PLINK utilities.

MetaWare isn't a terribly well known company, but it has the most enthusiastically loyal customers I've seen in this industry. MetaWare code is particularly transportable, and they have compilers and code generators for just about everything from mainframes to Z80s and cross compilers for most. Much of the 386 version of Symantec's newest Q&A was done with a 386 version of the MetaWare compiler.

I have been shown a debugger Borland is developing that is better than Codeview; it's supposed to be out before the end of 1987 and will greatly strengthen the utility of Turbo C for big production jobs.

I refuse to draw any conclusions from all this. Every one of these compilers has enthusiastic support from people I respect.

Winding Down

I want to mention again Avant Garde's pc-ditto, which, so far as I can tell, runs *every* PC program on an Atari ST. Some of them run pretty slow, but they all run; the emulation is down to the chip level. If you have a 5¼-inch disk drive, you can even run copy-protected software. If you've got an Atari, you probably need this program.

Another one I've set out for a look is OWL International's Guide, billed as "Hypertext for Personal Computers." I reviewed the Macintosh version of Guide a couple of months ago. Now they have one for the IBM PC. With luck, I'll get to that next month.

The game of the month is Infocom's Bureaucracy, written by Douglas Adams. Larry Niven got so engrossed with this thing that I had to help him—and ended up myself asking for help through BIX. One of its features is a flier for a magazine, *Popular Paranoia*, which every month gives you something new to worry about. Just be sure you don't eat the Zalagosian stew.

The book of the month is by C. J. Date, *An Introduction to Database Systems* (Addison-Wesley, 1987). This book has told me a great deal more than I wanted to know about databases; but it turns out I *did* want to know many things I never thought I had. This is not easy reading, but there's a lot of solid information.

A ton of new equipment came in today; I think I have a test bed for some of my other update and speedup PC boards. And now I'm off for the Westercon science fiction convention. ■

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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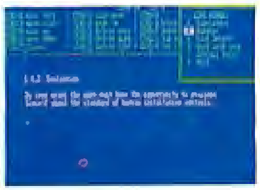

You can choose between running these programs in Original mode (99% compatible) – or in *Super Mode* with state-of-the-art Windows on all levels.

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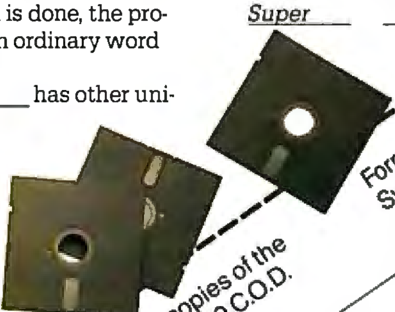

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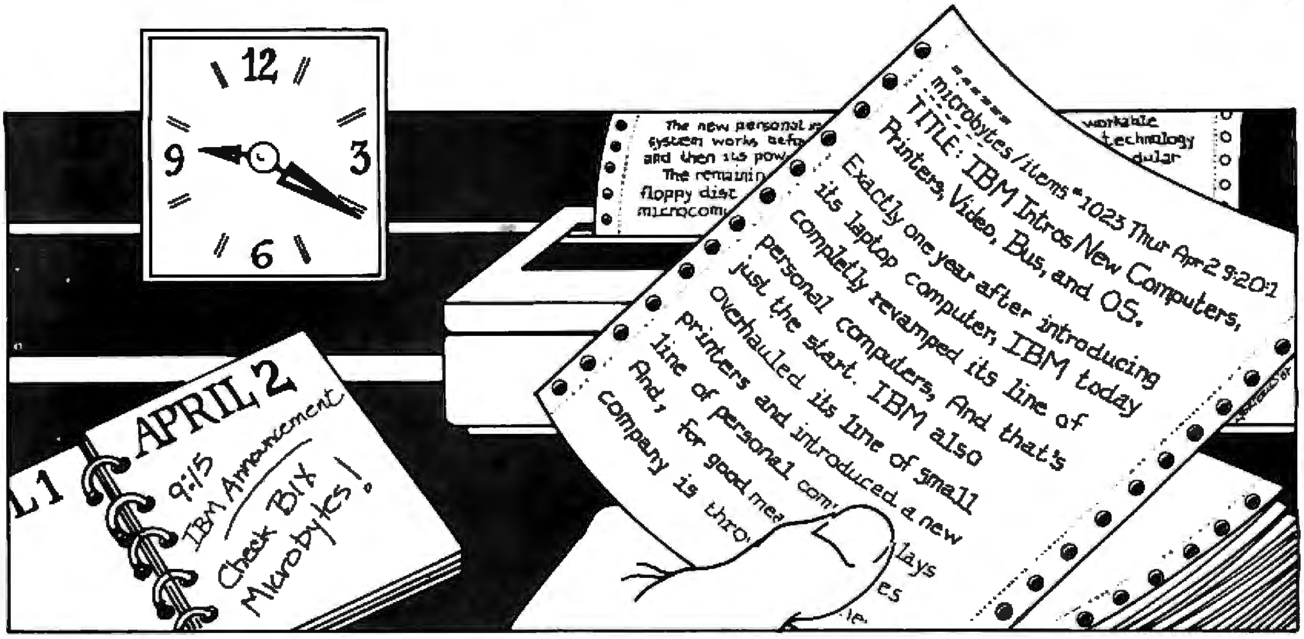

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Into the 4th Dimension, Part 1

Ezra Shapiro

First impressions of 4th Dimension on the Macintosh, E-mail updates, and more

This was going to be the month for 4th Dimension (Acius, $695), the new Macintosh database manager and application development system originally called Silver Surfer. It's an important product that will almost certainly be a major contender in the marketplace.

Unfortunately, it takes time to evaluate a relational database manager, particularly one that boasts full programmability and control of just about everything you'd ever need to control on the Mac, including the ROM Toolbox and serial-port access. Five weeks of intermittent testing have not been enough for me; at this point, I can only offer some preliminary reactions.

At first, I found myself mildly disappointed with the product. I had wanted 4th Dimension to be as easy to use as PFS:File on the IBM PC or Microsoft Works on the Mac, with the programmability of R:base or Paradox, and the flexibility of access to the Mac Toolbox—all without the need to learn programming syntax. Of course, this superprogram had to be faster than anything else out there.

By the time I received my copy from Guy Kawasaki, former Apple evangelist who now heads up Acius, I had heard so much gossip touting 4th Dimension as the best database manager ever sold that it couldn't possibly have lived up to my expectations. I think this is going to be a problem for the product for awhile, through no fault of the developers. The Mac community—perhaps the whole microcomputer universe—is so starved for a better way to manage data that any new package is going to fall short of hopes and dreams.

As a pure database manager, 4th Dimension is not as easy to bring up as some of the more elementary filing programs. Though you can start out immediately by defining fields for a new database (one of the things I loved about dBASE II), you have to design entry and report forms before you can begin to work with data.

The icons used within the program are not as cryptic as some I've seen (look at Helix if you want an example), but you might have some trouble figuring them out. To get anywhere at all, you simply must crack open the manuals and read about what's going on. So 4th Dimension is not as inviting to the novice as I had wished.

However, once I got the point, which is that 4th Dimension is a development environment, I lost my initial hesitation. The program is not intended as a tool for idiot users—it's a way to build applications for them, and it's extremely good at that.

You can code a program by writing in a stylized programming language, you can build routines by pulling procedures and operators from menus and dialog boxes, or you can even draw a graphic flowchart of an application and have 4th Dimension write the program for you. All the way through, you're in charge, and you can switch among forms of program creation as you desire. It's all very slick, and the program is exceptionally fast at realizing a completed project.

What if you're a single user who just wants to use the database functions? Well, you have to change the way you think about databases. If you cast yourself in the role of a programmer designing an application for yourself as a user, you'll do fine. This is a subtle shift in concept, but it works.

I'm still caught up in that transitional process, just coming up to speed with 4th Dimension. I've been trying to craft an application or two or three, then do a little debugging, then change things around. I'm learning. I haven't begun my performance testing, and I haven't even decided if raw speed matters at all with this program. I think this may turn out to be a favorite package, but I'm not quite ready to vote.

So you'll have to wait until next month for the second installment. To be continued.

Fallout

As part of my 4th Dimension evaluation, I needed a good batch of data to form the basis for a test suite. My rules were simple. I wanted a 10,000-record database made up of real-world information, and I couldn't use 4th Dimension to build it. I decided that since I write about applications, I should use application software to pull this sample database together. The project turned out to be tougher than it looked on the surface; I would have been better off learning a new programming language from scratch rather than using applications.

Acquiring the raw material was easy enough; I collected lists of names, lists of companies, lists of titles, and lists of cities from various on-line databases. I used Excel on the Mac to randomly generate lists of telephone numbers and ZIP codes. But whipping the lists into shape and compiling them into a database became a nightmare. The lists had to be cleaned up, capitalization standardized, and the data scrambled. Then everything had to be pulled into one enormous file. Here are some of the winners and losers among the application programs I tried.

No word processor on the Mac is particularly good with columnar material; I had to ship many of the lists over to the Tandon AT clone to process them. MicroPhone 1.1 beat out Red Ryder 9.4 as the telecommunications package on the Mac; Red Ryder tops out at only 9600

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.

bits per second, which is far too slow when you're cabling machines together and sending huge files.

Once I had my lists on the Tandon, XyWrite III was the most successful tool for getting all the text capitalized normally. MS-DOS Word 3.1 choked on my large files (the major problem was the Undo buffer—I was constantly running out of memory). WordStar 3.3 had no real problems, but it was s-l-o-w. XyWrite was frighteningly quick, and its programming/macro facilities were a tremendous help.

Back on the Macintosh, both Excel (spreadsheet) and Works (spreadsheet and database) failed me. They're snails at importing and exporting text (remember, I'm talking about 150,000 cells of data). FileMaker Plus had the easiest and quickest algorithms for importing columns of data into an existing file; it became my choice for pulling the lists into database format. Borland's Reflex for the Mac came in second, but its automatic indexing turned my giant database into an ugly, bloated monster.

Editors' Lifesaver

I've seen a lot of file-comparison programs. Most of them are line-oriented; that is, they show the difference between two files by printing a changed line in the later file underneath the appropriate line from the first file. This may be fine for looking at program listings, but it's inadequate for text documents. Once a long insertion or deletion changes the length of even one line, many line-oriented comparison programs are out of sync forever.

CompareRite (JURISoft, $129.95) is a file-comparison program optimized for text, and it's a dandy. It comprehends the file formats for most major MS-DOS word processors, and it's phrase- and paragraph-oriented. That means it can resynchronize itself neatly and provide an intelligible record of changes in prose documents. Also, CompareRite displays changes within the body of your text, or following the document as end notes, rather than beneath it.

You feed the program the filenames from your original document and the revised version and indicate the character attributes that you'd like to see both for phrases deleted from the original and phrases added to the revision. CompareRite spits out a new file combining the two with, for example, deletions shown in italic and insertions shown in boldface. These display options are limited only by the ability of your word processor. If you like, you can dump the comparison output to your screen and indicate changes in different colors.

It's all fast and simple. You can change word processors by invoking the program with a command-line parameter; display attributes can be changed from the program's easy menus. Not much more to it.

My only caution is that CompareRite is best for showing the editing of documents relatively late in the process; you wouldn't want to use it to compare versions of a document that has been completely reorganized or rewritten. It's perfect for legal work, where slight changes in wording are of paramount importance.

The program disk comes to you copy-protected, but removing the protection is not particularly odious. Just call JURISoft's toll-free number to register the software, and they'll tell you how to eliminate the protection scheme. You don't have to spend extra money or wait for a disk by return mail.

Nothing at all went wrong when I tested the program. If you need it, buy it.

Electronic-Mail Afterthoughts

In July, I wrote about Lotus Express and Desktop Express, two software packages that automate dealing with MCI Mail. So far, I've received more correspondence about that column than any other I've written. From users, the basic response seems to be that while the interface to Lotus Express is every bit as awful as I reported, I severely undervalued the product's utility. MCI addicts in the MS-DOS world apparently can't live without it. So I'm backing off, a little, from my condemnation of Lotus Express.

The program is a memory hog with a miserable interface, but if you use MCI Mail a lot, you should probably take a deep breath and buy it; those who use it regularly swear by it.

I also got quite a bit of mail, mostly via MCI Mail, from software developers working on electronic-mail products. At last count, the scorecard read: four companies with "universal" electronic-mail packages designed to provide a standard interface for all your electronic communications; two companies offering microcomputer-to-microcomputer products for messaging without the use of commercial systems; one OEM-level product that lets you develop your own interface to MCI Mail; and one mail system built into Ashton-Tate's Framework. Of these vendors, I'd only heard of two, and neither of those are known for telecommunications products. I'll have more to report when I've sorted it all out.

Finally, hats off to Bob Frankston of Lotus and Tom Evslin of Solutions (the firm that developed Desktop Express for Dow Jones). Those two gentlemen broke through corporate protocols and talked to each other; as a result, their products can now talk to each other. PCs and Macs can exchange binary files over MCI Mail with ease.

continued

Items Discussed

CompareRite $129.95
JURISoft Inc.
763 Massachusetts Ave.
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(617) 864-6151

Desktop Express $149
Dow Jones Software
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Princeton, NJ 08450
(609) 452-2000

FileMaker Plus $295
Forethought Inc.
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Sunnyvale, CA 94086
(408) 737-7070

4th Dimension $695
Acius Inc.
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Suite 495
Cupertino, CA 95014
(408) 252-4444

Guide
Macintosh $134.95
MS-DOS....................$199.95
OWL International Inc.
14218 Northeast 21st St.
Bellevue, WA 98007
(206) 747-3203

Lotus Express $100
Lotus Development Corp.
55 Cambridge Parkway
Cambridge, MA 02412
(617) 577-8500

MicroPhone......................$149
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(415) 644-3232

XyWrite III.......................$395
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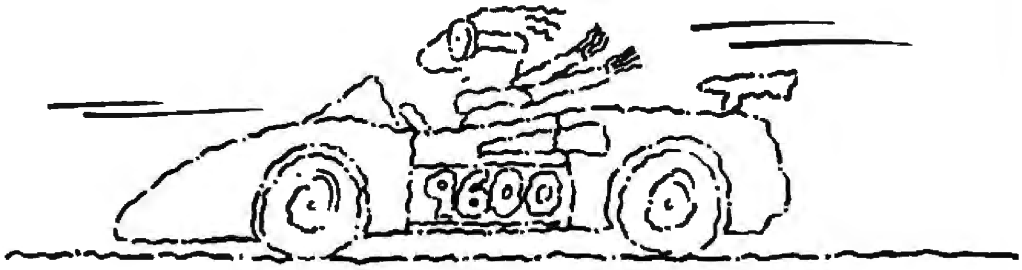

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There's only one "gotcha" in this file-transfer system; you can't use MS-DOS computers to receive programs for Macs. Lotus Express receives binary material from Desktop Express as three distinct blocks. The first block is the Macintosh file-header information, which Lotus Express interprets as an ASCII MCI message. Next comes the data fork, which Lotus Express accepts as an attached binary file. The third block is the Macintosh resource fork; Lotus Express can't understand it and ignores it.

Anyone transferring binary data files, like spreadsheets, will have no trouble; Mac resources are not often used in data files. However, this does rule out using a PC as a mail server if you intend to receive Mac programs and distribute them later. I don't suspect many people are dedicating machines to electronic mail yet, so I see this as a minor flaw. But if you're planning to get real fancy with MCI Mail, be warned—PCs will choke on Mac programs unless you go through that archaic BinHex ritual. If none of this makes any sense to you, that means you're safe.

Mea Culpa

After the first column in which I mentioned Guide, the hypertext system for both the Mac (and now the PC), I received a rather embarrassing note from Professor Peter J. Brown at the University of Kent at Canterbury. He writes:

"As the person who originally developed the basic ideas behind Guide, I was pleased to read your generally kind review. . . . My pleasure was dashed, however, when I came to the end and found credit given to the University of Edinburgh rather than to my University, the University of Kent. To put it in your terms, it was a bit like an American athlete winning an Olympic medal, and then the band playing the Russian national anthem by mistake.

"I would be glad, therefore, if you could find the space to correct the attribution. I might add that I am more than happy for the major credit to go to OWL [OWL International Inc.], who have taken my basic research ideas and successively enhanced them and turned them into a successful and well-marketed product.

Yours sincerely,
P. J. Brown
Professor of Computer Science"

Whoops. In my feeble defense, I note that OWL's press package mentions a research arrangement with the University of Edinburgh. However, elsewhere in the same paragraph, OWL correctly locates Professor Brown at Kent. Apologies to all concerned. ■

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The Best of BIX is a quick glimpse at just a few of the thousands of messages exchanged every month by BIX users. If you'd like more information on BIX, see the advertisement on page 267.

MACINTOSH

The Macintosh section this month is taken up entirely with a extended discussion of numeric performance of the Macintosh II and that ever-controversial subject among BIXen: benchmarks.

THE GREAT MAC II COPROCESSOR AND BENCHMARK DEBATE

macintosh/mac.ii #292, from tomwallace (Tom Wallace), Tue Jun 23 09:34:47 1987.

```
I have just run a few benchmarks on the Mac II and the Compaq
Deskpro 386 with a 387:

Savage (transcendental functions):
    Compaq 386/387          5.5 sec (10,000 iterations)
    Mac II                  101.0 sec (10,000 iterations)

Sieve (integer arithmetic):
    Compaq 386/387          188 sec (1000 iterations)
    Mac II                  117 sec (1000 iterations)
```

Both of these were run using the appropriate version of Turbo Pascal. The Mac II version included the "uses SANE" specification but defined its own Tan function (in the Savage benchmark) to stay as close as possible to the Compaq version.

My question is, why is the Mac II so slow at floating-point? I'm sure the 68881 is capable of much better performance. Is there really a 2000 percent overhead in accessing the 68881 through the SANE, compared to generating in-line floating-point instructions?

It would be interesting to see some benchmarks run using something like Fortran/020, which I don't have. The two systems should be fairly similar in floating-point speed if the software doesn't get in the way.

macintosh/mac.ii #309, from bwebster (Bruce Webster), Thu Jun 25 21:49:17 1987. A comment to message 292.

I don't know what's wrong with Turbo Pascal, but the problem isn't with the Mac II. I just ran the Savage benchmark in Mac C (the 68020/68881 version); it did 10,000 (not 1000) iterations in 2.2 seconds. A version compiled on the Mac Plus in Lightspeed C (version 2.01) did 2500 iterations in 23.2 seconds (which would factor down to 9.3 seconds for 1000 iterations). The Mac C compiler makes direct 68881 calls, while Lightspeed goes through SANE.

macintosh/mac.ii #293, from lloeb (Larry Loeb, conference comoderator), Tue Jun 23 09:44:24 1987. A comment to message 292.

One of the background things going on for the SE accelerator boards review is that I am recoding the benchmarks with the Consulair C/020 compiler to investigate *just* that point. I'll let you know what difference it makes when *I* find out.

macintosh/mac.ii #294, from tomwallace, Tue Jun 23 17:00:23 1987. A comment to message 293.

Good deal. If you would post the benchmarks you're using, I can run them on the 386/387 for comparison. It's a shame that the SANE doesn't provide better performance with the 68881. It leaves existing software with no efficient way of using the floating-point hardware, and makes it difficult for developers to write software that runs on the whole Mac family and uses each to its fullest.

For a depressing illustration of how small the speed increase is, the same Savage benchmark referred to in message #292 ran on an SE in 880 seconds. Of the 9x speed increase, 2x can be accounted for by the difference in clock speeds, and another 1.5 to 2x by the wider bus and faster instruction execution. This leaves a speed increase of 2x resulting from the use of floating-point hardware rather than software emulation. I don't know a lot about SANE, but it seems like a revision could boost this a lot. Many of the operations required by the IEEE standard are done in hardware on the '881, anyway.

macintosh/mac.ii #295, from lloeb, Tue Jun 23 17:35:48 1987. A comment to message 294.

The source to the benchmarks may or may not help. What compiler it's compiled under may.

macintosh/mac.ii #310, from bwebster, Thu Jun 25 21:50:22 1987. A comment to message 294.

I'd like to see your source to Savage. It's hard to believe that the Turbo Pascal performance would be so poor. On the other hand, I have a patched beta of TP working on the Mac II, so maybe I should go test it myself.

macintosh/mac.ii #296, from lmeier (Lyle Meier), Tue Jun 23 21:28:21 1987. A comment to message 292.

I believe the '387 has built-in transcendental functions on the chip (i.e., a Sin or Cos or Tan instruction). Likely the 68881 does not; I don't recall. This could make a difference in the speed if the Mac was having to compute the Tan on the 68881 using software while the '387 was able to do it on the chip.

macintosh/mac.ii #301, from reviews6 (Joel West), Wed Jun 24 00:08:21 1987. A comment to message 296.

The 68881 has: Sin, Cos, and Tan; also Arc, Hyperbolic, and Arc Hyperbolic log10, log2, ln, and Exponential using 10, 2, and e square root.

Of course, not all compilers generate instructions for this. For example, Apple's MPW Pascal and C compilers (2.0 beta) use separate options for 68881 arithmetic and trancendentals, since the latter are slightly less accurate than SANE.

macintosh/mac.ii #303, from tom_thompson (Tom Thompson, BYTE), Wed Jun 24 08:46:24 1987. A comment to message 301.

The problem seems to be with using SANE calls with the 68881. We've talked to two vendors (one with an instrumentation package, one with a CAD/CAM program) whose products used

continued

trigonometric calculations extensively, and both had written code that accessed the 68881 directly for at least a 100% boost in performance. No, this isn't kosher from a device-independent-code standpoint, but the cost of device independence is that math performance is crippled. Apple is supposedly working on programmer tools to access the 68881 directly.

---

macintosh/mac.ii #304, from lloeb, Wed Jun 24 09:07:44 1987. A comment to message 303.

First pass with the Float benchmark shows a 10x increase in performance; not just 100%.

---

macintosh/mac.ii #305, from reviews6, Thu Jun 25 10:34:23 1987. A comment to message 303.

The MPW 2.0b1 Pascal compiler (now available from ADPA) has a 68020 toggle and two 68881 toggles. The first, -mc68881, does the arithmetic using the '881; the second, -d ELEMS881, does the trancendentals using the '881.

The MPW C 2.0b2 C compiler has similar options; I don't know if it is currently being sold by ADPA, but clearly, the final 2.0 will have it.

---

macintosh/mac.ii #312, from bwebster, Thu Jun 25 22:19:45 1987. A comment to message 309.

At this point, I don't know what's wrong with your benchmark. I just keyed up a quick version of Savage in Turbo Pascal, compiled it, and ran it with 1000 iterations; it ran in just about 9 seconds flat, or about the same speed (a little faster, actually) than Lightspeed C. Here's the complete source code:

```
************** SAVAGE BENCHMARK IN TURBO PASCAL **************
program Savage;
{$R-}
{$I-}
{$U-}
uses
PasInOut,PasConsole,SANE,MemTypes,QuickDraw,OSIntf,ToolIntf;

const
  ILOOP          = 1000; { number of iterations }
var
  I                     : Integer;
  A                     : Extended; { 80-bit precision }
  Start,Finish,Delta    : LongInt;  { for timing }
begin
  Write('Press return to start benchmark: ');
  Readln;
  Start := TickCount;
  A := 1.0;
  for I := 1 to ILOOP do
    A := Tan(ArcTan(Exp(Ln(Sqrt(A*A))))) + 1.0;
  Finish := TickCount;
  Delta := Finish - Start;
  Writeln('A = ',A:20:14);
  Writeln('time = ',Delta,' ticks');
  Readln
end. { of program Savage }
**************************************************************
```

I compiled this on the Mac II using TP 1.00e, a version patched to let you get back to Turbo Pascal after running a program (Borland says it's a ROM bug that they have to work around). It ran in 538 ticks; then I ran it on the Mac II and got the same results. Incidentally, that same code file took 4450 ticks (74.2 seconds) on the Mac Plus.

continued

---

macintosh/mac.ii #316, from tomwallace, Fri Jun 26 15:11:27 1987. A comment to message 312.

Yes, that's almost identical to my benchmark. I got 101 seconds (hand-timed) for 10,000 iterations, so there isn't any real disagreement about how long it took. My point was that SANE wasn't doing a good job of getting at the '881, and that existing PC software did a better job of using the 80387 than existing Mac software (and compilers) do using the 68881. One of the things that a well-designed SANE could do is allow portability across the whole Mac family without the necessity of including run-time checks for the presence of a coprocessor, which is what PC software generally does.

By the way, where did you get the TP patch? I got tired of rebooting while I was running those benchmarks.

---

macintosh/mac.ii #319, from bwebster, Fri Jun 26 18:49:21 1987. A comment to message 316.

Aha! I think your message said *1000* iterations, not *10,000* (which is why I was so startled by your timings). Makes me feel a bit better. As for SANE's performance with the 68881...yeah, I think it's pretty crummy, too. Two orders of magnitude are inexcusable.

---

macintosh/mac.ii #322, from dgoldsmith (David Goldsmith), Fri Jun 26 22:55:08 1987. A comment to message 319.

For compatibility, it was necessary for Mac II SANE not to use the built-in transcendentals on the '881. This is because these functions are less accurate than SANE's, and programs might have stopped working (or at least given different answers). Of course, SANE uses the '881 arithmetic for its own transcendental implementation. This is where you are seeing the big hit. Compiler options in MPW 2.0 allow you to use the '881 transcendentals directly.

---

macintosh/mac.ii #315, from tomwallace, Fri Jun 26 14:59:29 1987. A comment to message 309.

That's the point I was making.

    10,000 iterations in 2.2 seconds using 68881 directly
    10,000 iterations in 93 seconds using SANE

I know that the 68881, when directly called, will yield performance approximately equivalent to the 80387 (+/- a factor of 2). What I was concerned about was the gross inefficiency of the SANE in using the coprocessor. WHY will we have to face that huge overhead when using or writing any software that isn't specifically designed for the Mac II?

---

macintosh/mac.ii #318, from kswartz (Karl Swartz), Fri Jun 26 18:16:32 1987. A comment to message 292.

I did some benchmarks on the various floating-point options on some Sun 3/160s, which have a 16.67-MHz 68020 and a 16.67-MHz (?) 68881. These clocks are close to the Mac II, so the data should be relevant.

The compiler options I tested were -f68881 (in-line code for the '881) and -fswitch (links to a run-time module, which uses what's available, the '881 in this case). Looking only at the floating-point sections of my code, I came up with a 20x to 30x performance improvement by using the in-line code.

In this case, the -fswitch library should be little more than a function that does the in-line stuff, so I would expect the Mac II figures to be *at least* this large.

macintosh/mac.ii #386, from mboich (Mike Boich), Mon Jul 6 14:20:05 1987. A comment to message 292.

SANE definitely introduces plenty of overhead. In addition, SANE is pickier about calculating elementary functions than is the '881, so rather than one '881 operation, most trig functions generate a series of calls to PACK4. So, yes, your worst fears are true. To see the '881 really fly, get MPW, and set all the right compiler directives. (I don't have them handy, but you want to tell it that you have an '881, and that you aren't super paranoid about precision.)

macintosh/mac.ii #317, from tomwallace, Fri Jun 26 15:42:41 1987.

After reflecting a little about the discussion above, I'd like to expand on my comments. I believe that a standard numeric environment is a wonderful idea, but that the current SANE isn't doing its job well.

Isn't it nice programming a Mac for graphics and not having to worry about the hardware the program will run on? The SANE could offer the same flexibility and convenience for numeric calculation, if it took the responsibility for interfacing with the hardware (which it does) and offered reasonable efficiency (which it apparently does not, at least for floating-point calculations).

In the PC world, if you want a program to use the 80x87, you have two choices: Compile the program with 87-only code, preventing it from running at all on non-87 machines; or test at run time for a coprocessor, and include both coprocessor calls and emulation routines in the executable code, increasing its size and reducing its speed.

I *thought* that one of the purposes of the SANE was to prevent this sort of silliness. Was that a bad assumption?

macintosh/mac.ii #320, from bwebster, Fri Jun 26 18:52:05 1987. A comment to message 317. Comments.

The assumption was good; the implementation was bad. BTW, I got the patched version of TP direct from Borland.

macintosh/mac.ii #323, from dgoldsmith, Fri Jun 26 23:03:27 1987. A comment to message 320.

The implementation of SANE is about as good as you can expect a software implementation of 80-bit floating point, which calculates transcendentals accurate to the last bit of the mantissa-to-be. It also has to go through the trap dispatcher. Software floating-point, especially if it conforms to the IEEE standard, is just not fast. I know there are faster software floating-point packages for the Mac (Excel has one), but following the IEEE rules and delivering accurate results is much harder. SANE is useful for dealing with ill-conditioned numerical problems, which other floating-point packages just throw up their hands at. Try doing some real numerical work with a language that supports SANE vs. one that doesn't, and you can see the difference true IEEE arithmetic (not just IEEE-"compatible" formats for floating-point numbers) can make.

continued

IBM PC and PS/2

The first thread of this month's IBM PC and PS/2 section is a perfect example of how BIXen enthusiasm and teamwork get together to solve a difficult problem. That's followed by a short thread on setting up AT RAM above 640K bytes. We finish up with a peek at the PS/2 Model 60 and answer the elusive 64-head hard disk question for the PS/2 Model 80.

THE GREAT HARDWARE-INTERRUPT QUEST

ibm.pc/hardware #2728, from hamby (Larry Hamby), Fri Apr 24 23:02:27 1987.

Does anyone know what the address OC at F000:E837 refers to?

I'm receiving an intermittent hardware-interrupt error message at that address, and it may relate to a newly acquired incompatibility between my computer and my PCturbo 286e board. I believe Peter Norton's "Inside the IBM PC" has a table of addresses, in case anyone has that book.

ibm.pc/hardware #2730, from dmick (Dan Mick), Fri Apr 24 23:42:39 1987. A comment to message 2728.

Interrupt OCh is the IRQ4 (for COM2:) interrupt. It's at F000:E*9*37, I think. It is on my Zenith, and those addresses are the same as I recall. Could you be one digit off?

ibm.pc/hardware #2731, from hamby, Sat Apr 25 07:57:06 1987. A comment to message 2730.

I think I got the digits correct. I'm sure I'll get this interrupt message again soon enough to double-check. By the way, another person has suggested that an intermittent HW-interrupt message such as this could be indicative of a degenerating memory chip. What do you think?

ibm.pc/hardware #2732, from dmick, Sat Apr 25 08:06:44 1987. A comment to message 2731.

It just sounded too coincidental that it'd be the OC, what with the "hardware interrupt" (parity and IRQ4 are both HW) and the C and the address that's *almost* the OC address....

I don't know the system well enough. It seems odd that it'd give a message about an intermittent interrupt on anything but memory or an unallocated interrupt, though. Odd. Interrupts do occur due to parity checks. However, they are nonmaskable interrupts (NMIs) and occur on INT 2.

ibm.pc/hardware #2733, from hamby, Sat Apr 25 11:10:23 1987. A comment to message 2732.

How does this sound for a diagnosis: I pulled a jumper at location J12 (on my system), which includes IRQ2, IRQ4, IRQ5, and IRQ7. This jumper is supposed to control the clock/calendar. I had pulled this jumper to accommodate the turbo board. Now that the board is out of my system, would this be causing the message? By the way, I'm not familiar with NMIs. Care to enlighten me?

ibm.pc/hardware #2734, from dmick, Sat Apr 25 11:54:53 1987. A comment to message 2733.

You pulled one jumper that somehow affected all the IRQs? I'm confused. NMI is just the nonmaskable (read "can't stop this one") interrupt. (Of course, on the IBM, there's a different one out that really *does* mask it, but as far as the normal Clear Interrupt flag instruction and the Interrupt Controller chip are concerned, this one can't be stopped.) Usually, the parity interrupt uses NMI. Some resident debuggers take it over. There are programs around to simply ignore NMI, too, since sometimes memory can be a bit flaky, and, rather than hang the system, some would prefer to take a chance. Nine times out of nine and a half, the "parity error" is a slightly hot chip or a loose card or chip in the socket, and very intermittent. Anyhow, though I can't (now) remember whether you said PC clone or AT clone, which makes a difference (more IRQs around), on PC clones, IRQ4 is the serial port #2 interrupt (8 - IRQ0 - timer, 9 - IRQ1 - keyboard, etc.), and, if you had some sort of COM2 board that was glitching IRQ4, or if the new turbo board was using IRQ4 instead of 2 like most are safer doing, it might be that the system is saying "what's this serial interrupt when you haven't installed a handler?"

ibm.pc/hardware #2739, from hamby, Sat Apr 25 22:49:44 1987. A comment to message 2734.

One last treatise on my HW error message. This whole situation came about as follows: I was was using my Leading Edge Model D (with MS bus mouse and Orchid PCturbo 286e) and was on-line with some service or other when:

1. I got the HW-interrupt message. (I'm pretty sure.)

2. My screen went totally blank. (I'm sure.)

3. I attempted several cold boots to no avail (still no screen). It was hard to tell with no screen, but I don't think the machine was rebooting at all.

4. I called LE tech support. They advised me to pull the turbo board.

5. I pulled the turbo board.

6. Rebooted and everything worked fine again (at, alas, 4.77 MHz) and with the aforementioned intermittent HW error messages.

7. Called Orchid tech support.

8. They surmised that the board's "video chips" had failed.

9. I sent the board back to Orchid. (Several days pass.)

10. Orchid tech support called to tell me that my board was fine. They tried for days to duplicate my problem to no avail.

11. I'm now awaiting the return of my turbo board.

So, as you can see, I've had a traumatic computer experience and have yet to find the culprit. I've been using the turbo board for months with no problems. We'll really find some things out in a few days after I get the turbo board back and see if it works in the system. If it does, then I'll REALLY be paranoid. Maybe this whole thing was heat-related? In the meantime, I still get this weird HW-interrupt message once or twice a day.

ibm.pc/hardware #2740, from barryn (Barry Nance), Sat Apr 25 22:52:09 1987. A comment to message 2739.

Larry, how many COM ports do you have in your machine? Are they jumpered correctly for COM1/IRQ4 and COM2/IRQ3 (if you have two of them)?

ibm.pc/hardware #2742, from hamby, Sun Apr 26 13:53:04 1987. A comment to message 2740.

I have two COM ports. I took the lid off and checked how I have the jumpers configured. I did this according to Orchid's directions and also Microsoft's. (Remember, I have a bus mouse as well as the turbo board.) I yanked the jumper at IRQ2.

continued


SAY CHARGE IT!
W/AMERICAN SEMICONDUCTOR CHARGE CARD
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This means I have no jumper connected for IRQs 2, 4, 5, and 7. Interestingly, IRQ2 is supposed to control my clock/calendar, and yanking this jumper was supposed to disable the clock/calendar. It works the same now as it did before. One other note: This configuration worked fine for several months. If I had my jumpers set incorrectly, wouldn't the problem have presented itself immediately?

Oh yeah, the board for the mouse and the turbo have jumpers on them that control which interrupt they will utilize. Since all worked well and my crash was so dramatic (blank screen, no boot, etc.) and cleared upon pulling the turbo board, does it seem reasonable to assume that a simple "friction" connection (i.e., the board slot connectors) could have disconnected due to expansion or contraction? Of course, every time I have a problem, I think it's heat-related.

---

ibm.pc/hardware #2743, from barryn, Sun Apr 26 16:19:17 1987. A comment to message 2742.

Well, if the COM ports are jumpered and set up correctly, and if it worked for months beforehand with no problems...I'm left scratching my head over this one.

---

ibm.pc/hardware #2752, from hamby, Mon Apr 27 22:17:37 1987. A comment to message 2743.

At the risk of really beating a dead horse, and if the subject of my mysterious intermittent "Unexpected HW interrupt at..." hasn't become boring to the extreme, they have now disappeared! (No, I haven't changed anything, and the turbo board is not yet reinstalled.) Since none of us was able to figure out why they appeared, I don't imagine their disappearance is going to help us understand what it was all about. Sure feel confident in this machine. Uh huh.

---

ibm.pc/hardware #2753, from barryn, Mon Apr 27 22:27:54 1987. A comment to message 2752.

Mysteries are never boring (especially when it's your own machine!). If you figure out what's going on, be sure to drop a note here about it. I'd sure be interested.

---

ibm.pc/hardware #2754, from hamby, Mon Apr 27 22:32:09 1987. A comment to message 2752.

How ironic and at once embarrassing! As soon as I left the previous message, I signed off of BIX, and, while attempting to sign onto another service, I got "Unexpected HW interrupt at..." this time at a different address than before (0C at 01AD:138F). I'm starting to detect (maybe) a pattern to these occurrences. They either appear while I'm just sitting in DOS doing nothing or while on-line or attempting to get on-line. Might be COM-port-related, as suspected. (Imagine the sound of hair being pulled out.)

---

ibm.pc/hardware #2755, from barryn, Mon Apr 27 22:46:45 1987. A comment to message 2754.

Larry, what communications program are you using? That might provide a clue.

---

ibm.pc/hardware #2758, from hamby, Tue Apr 28 07:53:23 1987. A comment to message 2755.

I use Mirror (a Crosstalk clone) and also an odd, custom program that links "Managing Your Money" to Chase Manhattan Bank. This is a rather glitchy program anyway. Might be a clue.

continued

ibm.pc/hardware #2761, from greenber (Ross Greenberg), Tue Apr 28 10:30:42 1987. A comment to message 2758.

Sounds to me as if the interrupts are not being restored properly by one of your two programs. Try the following experiment. Boot your machine, run Debug, and type "d 0:30" in response to the "-" prompt. This will give you the interrupt vector address for the serial port. Do a print screen onto your printer. Now run each of your comm programs and exit from them as you normally do. Go back into debug and enter that "d 0:30" again and take a look at the hex numbers that print out. Are they the same as before you ran the code? If so, then ignore this message; the problem lies elsewhere. If, however, the numbers have changed, they indicate some massive nastiness going on. Do *not* continue using the program in question; there is a possibility, albeit a slim one, that an unwanted character coming in the serial port might cause damage to something. Possibly, those numbers might be the same, indicating that at least part of the mystery work is done. It could always be unmasked interrupts or a whole bunch of other things. I'd be more than interested in seeing what numbers Debug comes out with -- both before and after. My bet's on the Managing Your Money program...

ibm.pc/hardware #2757, from bomb (Jerry McReynolds), Tue Apr 28 04:25:15 1987. A comment to message 2754.

Larry, does this problem with the "Unexpected HW interrupt" occur when the phone rings? Sounds a little strange, doesn't it? You say that the problem occurs while at the DOS prompt or when using the COM port. Have you tried to COPY CON COM1 or COM2 to see if you could reproduce the problem? Another idea: Have you checked the interrupt vector contents after boot-up and then again after using your communications program? The communications program might not be restoring vectors. I remember when that same problem (oversight) bit me in the rump.

ibm.pc/hardware #2759, from hamby, Tue Apr 28 08:01:39 1987. A comment to message 2757.

Jerry, if you'll tell me how, I'll check the interrupt vector contents. Never done that one before, but I'm sure I'll be able to figure it out if you'll point me in the right direction.

ibm.pc/hardware #2760, from hamby, Tue Apr 28 08:17:55 1987. A comment to message 2759.

Aha! I was just able to duplicate the problem twice (but not three times) in a row. It happened when I was using the aforementioned Chase Manhattan Bank home-banking communications software. I got the HW-interrupt error message as soon as the program tried to use the COM1 port and before it actually had the modem begin dialing. I tried my diagnostics program out to check the COM ports also. I was able to get the error message once out of 10 tries so far.

ibm.pc/hardware #2763, from barryn, Tue Apr 28 19:06:02 1987. A comment to message 2760.

Larry, I think you and Jerry have hit on the problem. It appears the home-banking communications software is not resetting the COM port properly when it exits.

ibm.pc/hardware #2764, from hamby, Tue Apr 28 23:15:43 1987. A comment to message 2763.

Man, you guys are GOOD. It IS the Managing Your Money/Chase Manhattan communications software that is causing the problems. Further evidence to follow, but first the results of the debug session:

First 4 bytes before any comm programs:

63 FE 0C F0

Same 4 bytes after the comm MYM/Chase program:

5B 4D EB 1C

The numbers changed only after I used the MYM comm program. Mirror caused no problems at all. Earlier today after we started to suspect the MYM/Chase program, I tried the following and got these horrifying results: I ran the suspect comm program, exited, and ran a diagnostics program to check specifically the COM1 port. My diagnostics program happens to display the date and time. When I hit the "go" button to execute the test, I got a HW-interrupt message, and the date and time began clicking erratically through different time zones and centuries. I hit Ctl-Alt-Del to get out of this, and the system hung with the screen blank. The only thing that got me back to the beginning was a cold boot. I now know that what I thought was a bogus turbo board was nothing of the kind. As Mr. Greenberg suggests, the MYM/Chase software is causing serious harassment to my machine. Way back when I had my screen blank out after using this program with my turbo board installed, not even a cold boot would restore the screen. I had to yank the board. One more thing: After using the comm program, I couldn't do a print screen of the debug results. Print screen wouldn't work. I called Chase Manhattan tech support and was told to cold-boot after using the program in order to clear system memory.

Well, now that I've gotten used to the idea of home banking, I guess I'll have to quit. I wonder why they don't just fix their program? Surely there are others who are having the same problem. Is there any way other than trial and error to determine the health and integrity of my system at this point? Thanks so much.

ibm.pc/hardware #2765, from dmick, Wed Apr 29 01:47:06 1987. A comment to message 2764.

Instead of dumping the program, get "tsr21.arc" from IBM.ARC. Run MARK.COM before running the program, and then run RELEASE.COM afterward. It's normally used to dump TSR programs, but one of its functions is to restore all the interrupt vectors as they were before you ran MARK (MARK saves 'em; RELEASE restores 'em). It's pretty foolproof.

That's a pretty silly way to go about the process. It's *very* easy, in assembly language or a high-level language, to restore the interrupt after you've used it. That's nothing but completely irresponsible programming. I wouldn't worry about your system...the problem will most likely go away if you reboot or if you use MARK/RELEASE. At least, I'd be amazed if it didn't go away.

ibm.pc/hardware #2766, from bomb, Wed Apr 29 02:45:02 1987. A comment to message 2764.

"GOOD," yeah, maybe... experienced most definitely... Glad to hear that you found the culprit! See, computers *are* really fun, aren't they? If you're calling that a bad crash, well, my little blue has had too many bad crashes to count, and it still keeps ticking (a bit slower, though). Did you smell anything funny after any of the crashes? I can remember taking out 11 computers at the same time, one 8088-based system talking to ten 8039-based systems. The system used 24VDC solenoids to move deflectors. I activated the solenoid with a 100-microsecond pulse of 70VDC and held it closed with 20VDC. Well, in that short window of time the code went somewhere (not where it was supposed to), and it never released the 70VDC. Needless to say,

continued

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24VDC solenoids don't last too long with 70VDC applied. It probably took 20 seconds to notice the smell of burning solenoid, another second or so to react, too late, before I could reach the Big Red Switch, poof, poof, poof, ... wisp of smoke... and a CRACK later. Well, that's all she wrote, the solenoid shorted, causing the TIP117 driver transistor to short, causing the 75468 to short, putting +70 volts on a +5 volt signal supplied by an 8255A, the 8255A went through meltdown putting +70 on the bus, and it was all over but the crying. BTW, not a single fuse blew! Anyway, I'm glad we could help.

---

ibm.pc/hardware #2767, from greenber, Wed Apr 29 08:27:40 1987. A comment to message 2764.

Glad to see we could be of assist. There are a couple of alternatives now. The first would be to junk the program, which is the easiest. Moving on to techie stuff, you can make a little program that will save and restore these interrupt vectors before and after you run the blasted program. There's a little more to this than meets the eye, since you have to twiddle with some bit ports to actually turn interrupts on the given COM port off. There is Dan Mick's suggestion, using the MARK and RELEASE package, which will restore the interrupt vectors *but* will not turn the interrupts off.

---

ibm.pc/hardware #2768, from barryn, Wed Apr 29 09:50:16 1987. A comment to message 2764.

Larry, as Dan suggests, using MARK before running the home-banking program and then issuing a RELEASE afterward will restore the interrupt vectors to their proper values. However, it sounds like the COM ports are still "active" when the bank-communications program finishes. To reset both COM ports to an inactive state, try running the following program after the home-banking program but before RELEASE (in other words, and perhaps in a .BAT file, run things in this order: 1) MARK, 2) the home-banking program, 3) RESET.COM (the TP program that follows), and 4) RELEASE).

```
100   rem
200   rem          a program to deactivate COM ports
300   rem
400   MCR% = &H03FC
500   IMR% = &H0021
600   IER% = &H03F9
700   Out MCR%, 0
800   Out IMR%, Inp(IMR%) OR &H0010
900   Out IER%, 0
1000  MCR% = &H02FC
1100  IER% = &H02F9
1200  Out MCR%, 0
1300  Out IMR%, Inp(IMR%) OR &H0008
1400  Out IER%, 0
1500  End
```

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ibm.pc/hardware #2775, from hamby, Wed Apr 29 23:24:23 1987. A comment to message 2768.

IT WORKS!!!! I've got the whole little bundle in a couple of batch files. I call up the comm program with one keystroke. It MARKS the memory position and then starts the comm program. After I exit the program, I hit one key and it RELEASES the memory and then runs the program, which resets the COM port. I know it works, because before I was always left with my modem in auto-answer mode until I entered another comm program and turned it off. This, of course, was a result of the unreset COM port. Let's hope there's no other weirdness now from this bizarre

continued

program. Now, for "neatness and appearance," is there any way that I can get from BASIC's "OK" prompt back to DOS automatically, or do I have to type "system" myself? Thanks again. You are obviously a man of rare caliber and breeding.

ibm.pc/hardware #2776, from barryn, Wed Apr 29 23:27:42 1987. A comment to message 2775.

Terrific, Larry! Glad it works. As to the "OK" prompt in BASIC, just replace the End statement with a System statement, and it'll return to DOS automatically.

SETTING UP A +640K PC AT RAM

ibm.at/hardware #1687, from jcrouch (Jack Crouch), Sun Jun 7 23:49:32 1987.

Can anyone help me with what will probably seem a simple problem? I have an AT clone with 1 Mb of RAM. Is there any way to use the RAM above 640K for anything, such as a RAM disk? My venture into the MS-DOS manual only confused me more than before. I got the impression that only RAM (like EMS) above 1 Mb could be used. Help!

ibm.at/hardware #1688, from irae (Ira Emus), Mon Jun 8 00:41:45 1987. A comment to message 1687.

You should be able to use at least part of it as a RAM disk with vdisk.sys. Add this to your config.sys:

```
device=vdisk.sys 384 /e
```

ibm.at/hardware #1692, from sbrodie (Scott Brodie), Tue Jun 9 22:17:31 1987. A comment to message 1687.

It depends on your clone. Apparently, the memory mapping of the RAM beyond 512K is not standardized, as the original IBM ATs had only 512K. Most clones allow you to chose between two or more configurations, usually by means of jumpers or DIP switches on the motherboard. You'll have to check the hardware manuals that came with your machine (though these are often little or no help). Many clones, unfortunately, give you only the Hobson's choice between allocating 512K as regular memory and 512K as extended memory (which would be accessible under MS-DOS only via the DOS RAM-disk utility), or allocating 640K as regular memory (maximizing the memory available to regular DOS applications), leaving the remaining 384K UTTERLY INACCESSIBLE! You may be able to use 64K RAM chips in place of the 256K chips that fill out the upper 512K, bringing the RAM on the motherboard to an even 640K; and use the 256K chips on an EMS or other memory-expansion board, where they might actually be of some use. I have seen a few clones that do allow the "obvious" allocation of 640K to DOS, and 384K as extended memory, suitable for a small RAM disk. If you select the 512/512 allocation, you should be able to come up to 640K for DOS using the first bank of a memory-expansion card, many of which (such as the Intel AboveBoards) come with 128K installed for just this purpose.

MODEL 60: PROBLEMS AND IMPRESSIONS

ibm.ps/model.50 #281, from bfernandez (Brian Fernandez), Sat Jun 27 23:25:29 1987.

My company has two Model 60s, and we've noted the following problems and behavior that may be of interest:

1. The IBM memory-upgrade kit does not fit on the motherboard properly, and the system does not react well to its installation (it does not use the space). If you install expanded memory, it ignores the motherboard and goes to the installed additional memory. Thus, if you install an incremental 1 Mb, you do not get 2 usable, but only 1. You must go to Orchid to get extended memory that works -- the IBM board will not be out until October, so until then there will be no memory upgrades. This obviously has implications for speed and running a relational DBMS under Windows, for example.

2. Some of the keyboards do not use the right Ctl & Alt with some programs.

3. The Quietwriter III with sheet feeders is a super machine!

4. We have not been able to use software copy programs to break the 5.25-to-3.5 transfers successfully in the event Assign A=B doesn't work. There is some problem with this we do not know about yet.

5. When booting you get all kinds or error codes (and a frozen system) if the software isn't properly copied onto C:. To cure, just remove the installed option and install proper software before booting!

6. The IBM internal modem, while restricted to 1200 bps, seems to work just like a Hayes with Smartcom, as well as the recommended Crosstalk.

7. We have found the ibm.cache + access time on the disk to enhance the speed considerably -- reading the clock speed or Norton reading is a totally unreliable measure of the real speed under loading. We are not talking serious LINPACKs, but it is a very fast machine for programs requiring heavy disk access.

8. If you lose your keys, as we did on installation, a locksmith will have no trouble drilling the old one out and installing a new one, but tape the system vents before he drills so metal particles do not get into the machine.

9. Our conclusion is that the 60 is a really good, solid box with a lot of future growth potential that, with incremental memory (which it badly needs and cannot get at this point), will operate very well in a windows or DOS or OS/2 environment. We plan to buy a number more and standardize on it.

ibm.ps/model.50 #283, from kkonnerth (Karl Konnerth), Tue Jun 30 23:31:54 1987. A comment to message 281.

I am also very happy with the Model 60 so far. However, I don't believe there is a motherboard memory-expansion option - it all has to be done with expansion cards. What were you doing? Also, Fort Software (in Kansas) and Vericomp (in San Diego) both offer true EMS drivers for the plain old IBM extended-memory boards. They take advantage of a bank-switching feature that was designed to map bad 16K segments of memory out of the address space, and they are supposed to run as fast as a true (E)EMS board - unlike EMS emulators for the AT extended memory. Also, Central Point advised me to first break copy protection on the 5.25, and then copy to 3.5. I'm just trying to avoid CP software (except 1-2-3, where I am patiently waiting for an upgrade). Finally, I haven't seen much of the problem you describe with the Ctl and Alt keys - what software does it occur with?

ibm.ps/model.50 #287, from swnev (Scott Neville), Mon Jul 6 23:42:23 1987. A comment to message 283.

None of the programs I use work with the right Alt key. These include Turbo Pascal, BASICA, Brief, PC-Write, and a whole slew of other programs.

continued

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The diagnostics on the reference disk recognize the right Alt key, and the keyboard tutorial on that disk performs as it should using the right Alt key.

I will run the keyboard up to my local dealer as soon as I get the chance and see if the same thing happens on their system

---

ibm.ps/model.50 #286, from nickbaran (Nick Baran, BYTE), Sun Jul 5 22:32:05 1987. A comment to message 281.

There have been reports of these boot errors from a number of sources. Which software must be "installed correctly on drive C:" to avoid these errors?

64-HEAD HARD DISKS? THE GAME'S AFOOT

ibm.ps/model.80 #100, from awright (Mark Garetz), Fri Jun 26 01:24:19 1987.

Re: The hard disk in the IBM PS/2 Model 80 having 64 heads.

This seems unlikely, especially given the poor access time. Sounds like a bug in the program reporting the number of heads, *or* in an effort to control the add-on drive market, IBM has built a drive with an interface that has 6 binary-coded head-select lines but doesn't really have that many heads in the actual drive. A processor in the drive electronics could easily translate to the actual number of heads.

---

ibm.ps/model.80 #102, from schin (Sam Chin), Fri Jun 26 10:59:38 1987. A comment to message 100.

Not only did Coretest 2.7 report 64 heads, but when I low-level-formatted the disk using IBM's Model 80 utilities, they counted 64 heads. The DOS 3.3 Format program also counts 64 heads. (The 3.2 and 3.3 Format programs list the head and track as they are formatting.) I know it sounds unlikely for it to have 64 physical heads, but that would account for the phenomenal 800K-byte/sec transfer time.

---

ibm.ps/model.80 #105, from matt.trask (Matt Trask), Fri Jun 26 16:23:27 1987. A comment to message 102.

One of the tricks that is played with ESDI drives under DOS is logical to physical mappings of the heads or sectors to support DOS's assumptions (limitations?) about what a drive can have. F'r instance, both the Western Digital WA5 controller and the Omti 8621 can change a 34-sector/track drive into a 17-sector/track drive with twice as many cylinders. Something like this may be used to cause the mysterious 64 heads.

---

ibm.ps/model.80 #103, from matt.trask, Fri Jun 26 16:16:54 1987. A comment to message 100.

Don't know that I can comment on that one. I've only spent a half hour with a Model 80 so far. Sounds like someone's software may be making ST-506 assumptions about the ESDI drives, though.

---

ibm.ps/model.80 #120, from mvose (Michael Vose, BYTE), Wed Jul 1 10:01:00 1987. A comment to message 103.

Yes, the Model 80's disk controller does use relative block addressing and tricks MS-DOS into thinking that there are 64 heads. There are 64 *logical* heads and, apparently, a device driver to map logical heads to physical heads.

IBM is supposedly preparing a fixed disk technical reference manual that explains all this stuff. (I got my info from some off-hand comments made by some IBM engineers milling around when I ran some Model 80 benchmarks for BYTE on a visit to Boca.) ■

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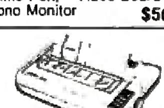

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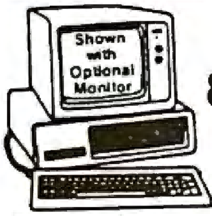

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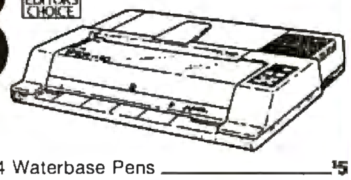

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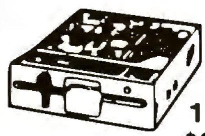

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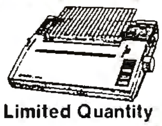

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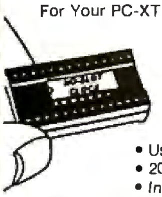

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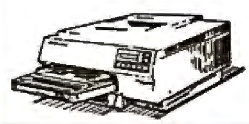

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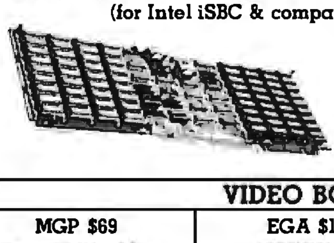

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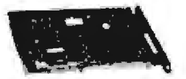

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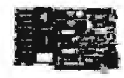

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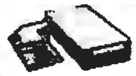

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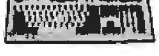

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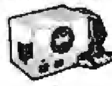

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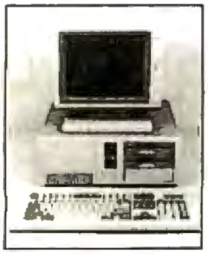

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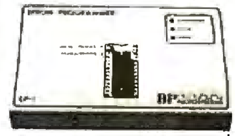

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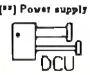

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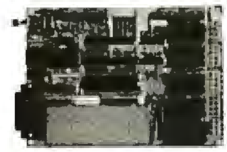

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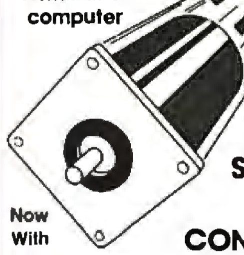

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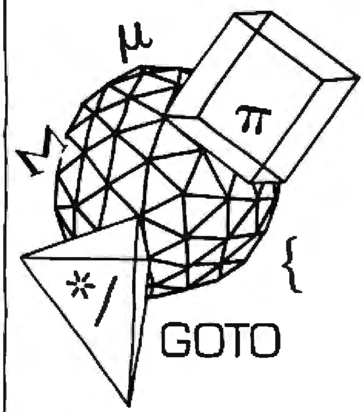

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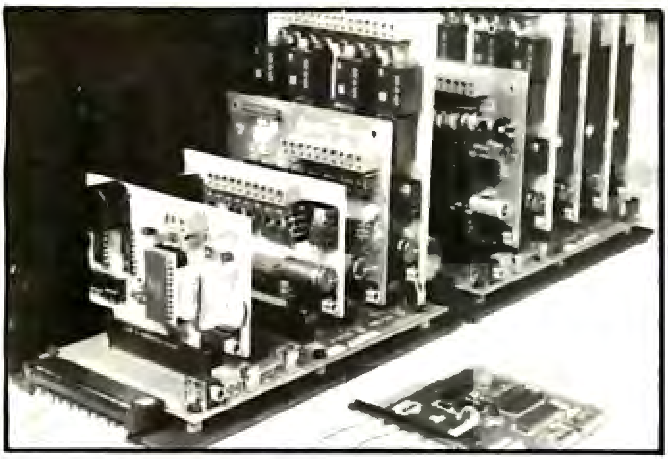

An A-BUS system with two Motherboards
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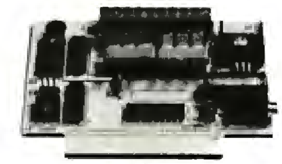

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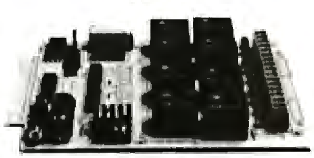

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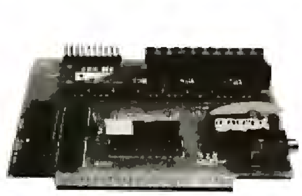

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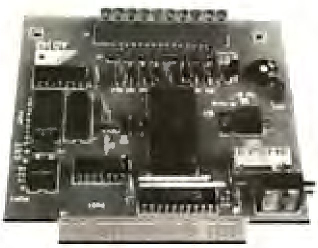

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Just a few years ago, illegal hunting and encroaching civilization had all but destroyed the alligator population in the south. They were added to the official list of endangered species in the United States.

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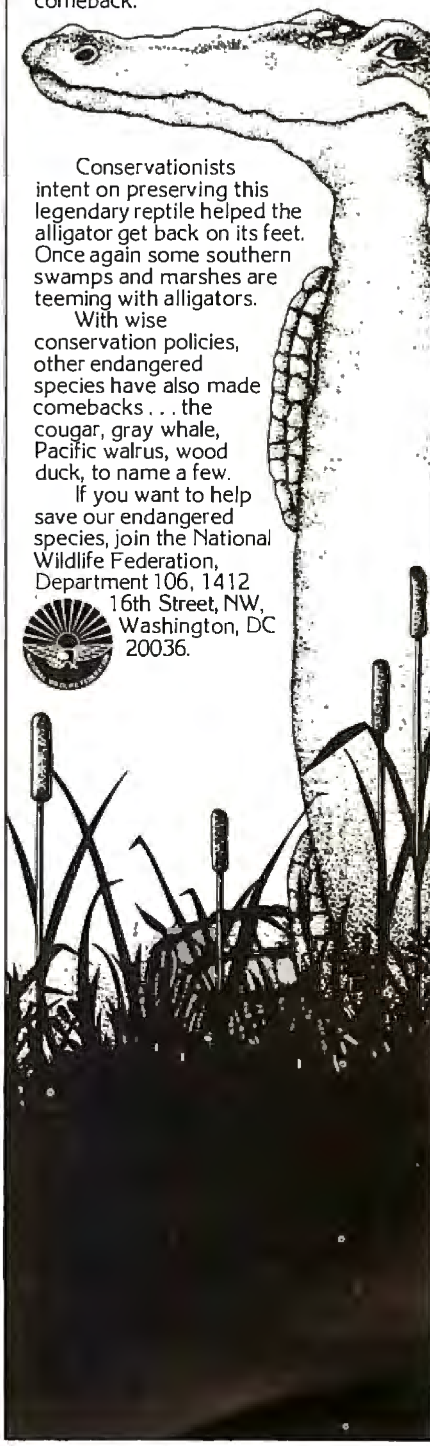


Conservationists intent on preserving this legendary reptile helped the alligator get back on its feet. Once again some southern swamps and marshes are teeming with alligators.

With wise conservation policies, other endangered species have also made comebacks . . . the cougar, gray whale, Pacific walrus, wood duck, to name a few.

If you want to help save our endangered species, join the National Wildlife Federation, Department 106, 1412 16th Street, NW, Washington, DC 20036.

PLOTTERS

The Sweet "P" 100 was private labeled for the Epson corporation under the Comrex Brand. This plotter makes short work of translating financial and numeric data into a graphic presentation. Many ready to run programs such as Auto/CAD and Lotus 1-2-3 already support this plotter.
The Sweet "P" 100 features programmable paper sizes up to 8½ by 120 inches, 6 inch per second plot speed and 0.004" step size. Easy to implement Centronics interface allows the Sweet "P" 100 immediate use with the printer port of most personal computers.
This is your opportunity to purchase a plotter which was originally priced at $795 for only $129.
Also available is a support package which includes demonstration software, interface cable, a multicolor pen assortment and a variety of paper.

HPGL ● 11" by 17"

$795

Western Graphtec Model 2000 operates under the Hewlett Packard graphic language and has both parellel and serial interface. Size "B" plotter, 11" by 17" flat bed with eight self capping color pens. Maximun plotting speed 10" per second, resolution .05mm with repeatability of .004".
To blow out the remaining inventory, California Digital has slashed the price of MP/2000 to $795. Hurry! only 180 plotters left.

PLOTTERS

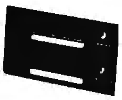
Sweet "P" 100 (Comrex) 8½ by 120"
Houston Instruments DMP29, 11 by 17
Houston Instruments DMP40, 11 by 17, B size
Houston Instruments DMP41/42C/D 24 by 36
Houston Inst. DMP51/52MPC/D, 14 pen
Houston Instruments DMP56, E size 34 by 44
Houston Instr. PC695, 11 by 17 multi-pen

659
419
99
[illegible]
[illegible]

20/20 Bernoulli Box

~~$3495~~

$1595



PRINT

IBM Thermal printer, 80 col., serial	$39	Panasonic P1080/I, 10" 120cps.	229
Fujitsu D830 80 cps., daisy wheel	759	Panasonic P1091/I, 10" 160cps.	299
Silver Reed EXP-800 136 col., 40cps.	729	Panasonic P1592 15" 160cps.	429
Juki 6300 daisy wheel 40 cps.	819	Star Gemini NX10, 120cps 10" NLQ.	239
NEC 8850 Spinwriter daisy wheel 55cps.	1159	Star Gemini NX15, 120cps 15" NLQ.	359
NEC P6/660P 10" 216 cps. NLQ.	469	Toshiba 321, 24 wire head 216 cps; NLQ.	519
NEC P7/760P 15" 216cps. NLQ.	659	Toshiba 341, 24 wire head 216 cps. 15".	629
Olympia NP80, 200 cps draft, 40 nlq.	329	Printronics P300 dot matrix, 300 LPM	3995
Olympia NP136, 15" same as above	459	Printronics P600 dot matrix, 600 LPM	5795
Epson FX86E NLQ 10" 240char/sec.	399	LASER PRINTERS	
Epson FX286E NLQ 15" 240 char/sec.	539	Apple Laser Writer Plus; Postscript	4295
Epson EX1000 300cps, NLQ/54cps.	599	QMS PS/800 2 meg. Postscript. 8 pgs.	4295
Citzen MSP-10 160 cps. 10"	299	Hewlett Packard Series II, laser printer	1795
Citzen MSP-15 160 cps. 15"	449	Texas Instr. OmniLaser 2108 P/S. 8 pgs.	4295
Okidata 182 80 column, par'l.	239	Texas Inst. OmniLaser 2115 P/S, 15 pgs	5595
Okidata 192+ 136 column, par'l.	345	Quadram Quad/Laser, 5 Megabytes	2995
Okidata 292 136 column, parellel.	489		

HEWLETT PACKARD

The Alphacom Daisy Wheel Printer was an excellent value at $495, but we have been asked to assist in liquidating the remaining inventory at only $99. The AlphaCom prints at 18 character per second, is 630 compatible, accepts Diablo daisy wheels and ribbons. Personality modules additional.

COMPUTER READ!

Omni-Reader... the first optical character reader **designed and priced for the small computer**

COPY:
•Manuscripts •Contracts •Articles
•Forms •Invoices

APPLICATIONS:
•Mailing Lists •Editing •Data Base Management •Transfering Information between incompatible systems

Uses a standard RS-232 serial port hookup to interface eaisly with your computer.

$35

We have them again... The Remex 480 was a sell out two years ago but we located an additional 10,000 units and are offering these 2/3 height IBM/PC compatible 360K/Byte drives at only $35 each at quantity two.

	One	Two	Ten
REMEX 480 ⅔ height for PC	39	35	29
TANDON 65L/2 360K, ½ ht.	79	75	72
TANDON 101/4 full ht. 96 TPI.	119	109	99
FUJITSU 5¼" half height	95	89	82
MITSUBISHI new 501 half ht.	119	109	105
MITSUBISHI 504A AT comp.	149	139	135
TEAC FD55BV half height	109	99	
TEAC FD55FV 96 TPI, half ht.	119	109	1
TEAC FD55GF for IBM AT	149	139	1
PANASONIC 455 Half Height	109	99	89
PANASONIC 475 1.2 Meg./96	119	115	109
Switching power supply			49
Dual enclosure for 5¼" drives			59

U.S. Robotics 2400

$189

The US Robotics Micro 2400 modem is one hundred percent Hayes compatible, auto dial, auto answer, auto everthing, loud-speaker included. A super value at only $189.

The Smarteam 2400 offers all the features of the Hayes Smart Modem 2400 for a fraction of the price. Now is your opportunity to purchase a 2400 baud modem for only $259.
Also available: The Smarteam 1200 at only $119

MODEMS

Avatex 1200 baud external, Hayes....................
Hayes Smartmodem 2400 baud modem.... ..
Smarteam 2400 Hayes Compatible ....
Team 1200 Hayes Compatible, 300/1200......
Smarteam 1200B IBM 1200baudcard ....
UltraLink 1200 data and voice, Bell202 .....
Prometheus 1200 features...
rometheus 1200B internal PC.........................
internal PC....

Five Inch Winchester Disk Drives

Price does not include controller.	each	two+
SEAGATE 225 20 Meg. ½ Ht.	269	259
SEAGATE 238 30 Meg. RLL	299	289
SEAGATE 4026 26 M. 35mS.	559	539
SEAGATE 4051 51 M. 35mS.	695	659
SEAGATE 4096 96 M. 35mS.	859	829
MINISCRIBE 3425 25 m 85ms.	279	247
MINISCRIBE 3650 50 m 61 ms.	419	399
FUJITSU 2242 55 M. 35mS.	1299	1229
FUJITSU 2243 86 M. 35mS.	1695	1619
RODIME RO-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M.	1829	1779
MAXTOR XT1140 140 Meg.	2595	2529
TOSHIBA MK56 70 M. 30mS.	1789	1729

Controllers for IBM/PC ●

XEBEC *1220 with floppy controller*	189
DTC 5150CX	119
OMTI 5520 half card	99
OMTI 5527 RLL controller	129
ADAPTEC 2070 RLL controller	179
ADAPTEC 2010A	159
WESTERN DIGITAL WD/1002WX2	89

● SCSI/SASI Winchester Controllers ●

XEBEC 1410A 5¼" foot print	219
WESTERN DIGITAL 1002-05E 5¼"	289
OMTI 20L	89

● Winchester Accessories ●

Installation Kit with manual
Winchester enclosure and supply
Dual 20/34 cable set
Switching power supply

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Mail Order Electronics • Worldwide

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FOR ORDERS ONLY 415-592-8097

ALL OTHER INQUIRIES 415-592-8121

NEC V20 & V30 CHIPS

Replace the 8086 or 8088 in Your IBM-PC and Increase its Speed by up to 40%!

Part No.		Price
UPD70108-5	(5MHz) V20 Chip	$ 8.75
UPD70108-8	(8MHz) V20 Chip	$10.75
UPD70108-10	(10MHz) V20 Chip	$29.95
UPD70116-8	(8MHz) V30 Chip	$13.75
UPD70116-10	(10MHz) V30 Chip	$29.95

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.65	.55
7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	2.05	1.95
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.55	.45
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.69	.59
7416	.39	.29	74143	3.95	3.85
7417	.39	.29	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.59	.49
7442	.55	.45	74175	.59	.49
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	2.05	1.95	74193	.79	.69
7472	.89	.79	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.65	.55
7476	.45	.35	74367	.65	.55

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.69	.59
74LS30	.29	.19	74LS243	.69	.59
74LS32	.35	.25	74LS244	.69	.59
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
74LS154	1.09	.99	74LS629	2.95	2.85
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.39	2.29

74S/PROMS*

Part No.	Price	Part No.	Price
74S00	.29	74S188*	1.49
74S04	.29	74S189	1.69
74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.49	74S288*	1.49
74S124	2.75	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74F

Part No.	Price	Part No.	Price
74F00	.29	74F139	.69
74F04	.29	74F157	.69
74F08	.29	74F193	2.95
74F10	.29	74F240	.99
74F32	.29	74F244	.99
74F74	.39	74F253	.69
74F86	.39	74F373	.99
74F138	.69	74F374	.99

CD—CMOS

Part No.	Price	Part No.	Price
CD4001	.19	CD4076	.59
CD4008	.69	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	2.49
CD4018	.59	CD40107	.49
CD4020	.59	CD40109	.79
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
CD4050	.29	CD4541	.89
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	4.95
CD4053	.59	CD4555	.79
CD4063	1.49	CD4559	7.95
CD4066	.29	CD4566	2.49
CD4067	1.29	CD4583	.89
CD4069	.25	CD4584	.39
CD4070	.25	CD4585	.89
CD4071	.25	MC14411P	8.95
CD4072	.25	MC14490P	4.49

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.	Price
D765AC	4.95
WD9216	6.95

Z80, Z80A, Z80B SERIES

Part No.	Price
Z80	1.25
Z80-CTC	1.79
Z80-DART	4.95
Z80-PIO	1.79
Z80A	1.69
Z80A-CTC	1.79
Z80A-DART	4.95
Z80A-PIO	1.69
Z80A-SIO/0	5.75
Z80B	3.49
Z80B-CTC	3.95
Z80B-PIO	4.29

6500/6800/68000 SER.

Part No.	Price
6502	2.65
65C02 (CMOS)	8.95
6520	1.95
6522	3.95
6532	6.49
6551	4.49
65C802(CMOS)	19.95
6800	1.95
6802	3.95
6810	1.25
6821	1.75
6840	3.95

6500/6800/68000 Cont.

Part No.	Price
6845	3.95
6850	1.95
6852	1.49
MC68000L8	11.95
MC68000L10	13.95
MC68010L10	49.95
MC68020RC 12B	169.95
MC68881RC12A	149.95

8000 SERIES

Part No.	Price
8031	3.95
80C31	9.95
8035	1.95
8073	9.95
8080A	2.95
8085A	2.49
8086	5.95
8086-2	6.95
8087(5MHz)	129.95
8087-2(8MHz)	169.95
8088	6.49
8088-2	8.95
8116	4.95
8155	2.49
8155-2	3.49
8156	3.95
8202	5.95
8203	9.95
8212	1.49
8224	2.25

8000 SERIES Cont.

Part No.	Price
8228	2.95
8237-5	4.95
8243	2.25
8250A	6.49
8250B (For IBM)	6.95
8251A	1.89
8253-5	1.95
8254	4.95
8255A-5	1.89
8257-5	1.95
8259-5	2.25
8272	4.95
8279-5	2.95
8741	9.95
8748 (25V)	7.95
8748H (HMOS) (21V)	9.95
8749	9.95
8751	39.95
8755	14.95

DATA ACQUISITION

Part No.	Price
ADC0804LCN	3.19
ADC0808CCN	5.95
ADC0809CCN	3.95
ADC0816CCN	11.95
ADC1205CCJ-1	19.95
DAC0808LCN	1.95
DAC1008LCN	4.95
AY-3-1015D	4.95
AY-5-1013A	2.95

MICROPROCESSOR SALE!

Part No.		Price
MC68000L8	16-Bit MPU (8MHz)	$ 11.95
MC68000L10	16-Bit MPU (10MHz)	$ 13.95
MC68000L12	16-Bit MPU (12MHz)	$ 17.95
MC68008L8	32-Bit MPU (8-Bit Data Bus)	$ 19.95
MC68010L10	16-Bit MPU (10MHz)	$ 49.95
MC68020RC12B	32-Bit MPU (12MHz)	$169.95
MC68701	8-Bit EPROM Microcomputer	$ 14.95
MC68705U3L	8-Bit EPROM Microcomputer	$ 10.95
MC68881RC12A	Floating Point Co-processor	$149.95

DYNAMIC RAMS

Part No.			Price
4116-15	16,384 x 1	(150ns)	.89
4128-20	131,072 x 1	(200ns) (Piggyback)	3.25
4164-120	65,536 x 1	(120ns)	1.75
4164-150	65,536 x 1	(150ns)	1.25
4164-200	65,536 x 1	(200ns)	.99
TMS4416-12	16,384 x 4	(120ns)	3.49
8118	16,384 x 1	(120ns)	.49
41256-120	262,144 x 1	(120ns)	3.95
41256-150	262,144 x 1	(150ns)	3.25
50464-15	65,536 x 4	(150ns) (4464)	4.95
511000P-10	1,048,576 x 1	(100ns) 1 Meg	34.95
514256P-10	262,144 x 4	(100ns) 1 Meg	29.95

STATIC RAMS

Part No.			Price
2016-12	2048 x 8	(120ns)	1.69
2018-45	2048 x 8	(45ns)	6.95
2102-2L	1024 x 1	(250ns) Low Power	1.95
2114N	1024 x 4	(450ns)	.99
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	2.49
5101	256 x 4	(450ns) CMOS	1.95
6116P-3	2048 x 8	(150ns) CMOS	1.89
6116LP-3	2048 x 8	(150ns) LP CMOS	1.95
6264LP-12	8192 x 8	(120ns) LP CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.49
6264LP-15	8192 x 8	(150ns) LP CMOS	3.75
6514	1024 x 4	(350ns) CMOS	3.49
43256-15L	32,768 x 8	(150ns) Low Power	11.95

EPROMS

Part No.			Price
TMS2516	2048 x 8	(450ns) 25V	6.95
TMS2532	4096 x 8	(450ns) 25V	6.95
TMS2532A	4096 x 8	(450ns) 21V	5.95
TMS2564	8192 x 8	(450ns) 25V	9.95
TMS2716	2048 x 8	(450ns) 3 Voltage	9.95
1702A	256 x 8	(1μs)	6.95
2708	1024 x 8	(450ns)	4.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	5.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	5.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	3.95
2764-45	8192 x 8	(450ns) 21V	2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V(CMOS)	7.95
27512-20	65,536 x 8	(200ns) 12.5V	13.49
27512-25	65,536 x 8	(250ns) 12.5V	11.95
68764	8192 x 8	(450ns) 25V	13.95

EEPROMS

Part No.			Price
2816A	2048 x 8	(350ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A	8192 x 8	(250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
WD1770	11.95
SI3052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	4.95
6526	14.95
6529	2.95
6532	6.49
6545-1	4.95
6551	4.49
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	14.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
*8721	14.95
8722	9.95
*251104-04	10.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
*325572-01	14.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

*No specs. available
**Note: 82S100PLA = U17 (C-64)

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. **COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION**

MM5321N $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	1.19
74HC04	.29	74HC240	.99
74HC08	.29	74HC244	.99
74HC10	.29	74HC245	.99
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.89
74HC32	.29	74HC273	.99
74HC74	.39	74HC373	.99
74HC75	.39	74HC374	.99
74HC76	.45	74HC595	1.29
74HC85	.79	74HC688	.99
74HC86	.39	74HC943	8.95
74HC123	.69	74HC4040	.99
74HC125	.49	74HC4049	.59
74HC132	.69	74HC4050	.59
74HC138	.49	74HC4060	.99
74HC139	.49	74HC4511	1.29
74HC154	1.49	74HC4514	1.79
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

Part No.	Price	Part No.	Price
74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C — CMOS

Part No.	Price	Part No.	Price
74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.79
74C08	.35	74C240	1.79
74C10	.35	74C244	1.79
74C14	.59	74C373	1.95
74C32	.35	74C374	1.95
74C74	.59	74C912	8.95
74C85	1.49	74C915	1.39
74C86	.35	74C920	6.95
74C89	5.49	74C921	6.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

Part No.	Price	Part No.	Price
DS0026CN	1.95	LM1458N	.39
TL074CN	1.19	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.89
LM311N	.45	MC1648P	3.49
LM317T	.79	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	1.49
LM323K	3.95	ULN2003A	.79
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	26LS29	3.95
LM348N	.69	26LS31	1.19
LM350T	2.95	26LS32	1.19
L 351N	.39	26LS33	1.49
LF353N	.49	LM2901N	.39
LF355N	.79	LM2907N	1.29
LF356N	.89	LM2917N (8 pin)	1.95
LF357N	1.09	MC3419CL	6.95
LM358N	.49	MC3446N	1.69
LM360N	2.19	MC3450P	1.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	1.95
LM386N-3	.89	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	1.49	LM3909N	.99
NE540H(C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XRL555	.59	NE5532	.69
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
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LM747CN	.59	7815T (LM340T-15)	.49
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		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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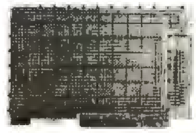
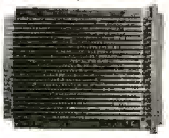
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection



JE417 (Pictured)

JE411 (6½", No Pads, Gen. Purp.) $12.95
JE415 (6½", No Pads, PC/XT) $14.95
JE417 (6½", Plated w/Pads, PC/XT) $19.95



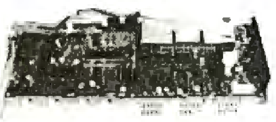
Extender Boards Designed for Troubleshooting and Testing

JE419 (Pictured)

JE419 (5¼" Extender, 22/44 Connector) . . $19.95
JE421 (4¾" Extender, 31/62 Connector) . . $19.95

Commodore VIC-20 Motherboard

CV20



May have to troubleshoot or just use for spare parts. CV20 Includes: (1) 6560, (2) 6522, (1) 6502, (2) 6116P-4, and much more!

CV20 (VIC-20 Motherboard) . . . . . $ 9.95
089033 (SAMS VIC-20 Schematics) . . . $19.95

Additional Accessories for Commodore VIC-20, C-64 & C-128

JE232CM (Pictured)

*CM1 (300B Modem VIC-20, C-64) . $19.95
*JE232CM (RS232 Inter. VIC-20, C-64) . $39.95
CPS10 (C-64 Power Supply) $39.95
CPS128 (C-128 Power Supply) $59.95

*Also compatible with C-128 in 64 mode only.

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Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TE512 Includes 512K RAM $119.95
TANC Plug-in Clock option chip (only) $39.95

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T20MB 20MB Hard Disk Drive Board for Tandy 1000 . . . . $494.95
SX20MB 20MB Hard Disk Drive Board for Tandy 1000SX $499.95

TANDY 1000 Multifunction Board with Clock Calendar

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(not included)

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JE1015	XT/AT Style Keyboard	$ 59.95
41256-120	512K RAM (18 Chips)	$ 71.10
JE1012	Baby AT Flip-Top Case	$ 69.95
JE1032	200W Power Supply	$ 89.95
JE1022	5¼" High Density Disk Drive	$109.95
JE1003	Baby AT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	$399.95

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SAVE $50.85!

JE1008 IBM™ AT Compatible Kit $799.95

Jameco's IBM PC/XT Compatible Kit

SAVE $77.15

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JE1040	Floppy Controller Card	$29.95
JE1010	Flip-Top Case	$34.95
JE1015	XT/AT Style Keyboard	$59.95
JE1030	150 Watt Power Supply	$69.95
JE1050	Mono/Graph. Crd. w/P.Port	$59.95
JE1020	5¼" DSDD Disk Drive	$89.95
GREEN	12" Mono. Green Monitor	$99.95
JE1000	XT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	$89.95

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Jameco's 4.77/8MHz Turbo IBM Compatible Kit

Same as JE1004 except comes with 640K RAM, JE1001 (Turbo) 4.77/8MHz motherboard, JE1071 multi I/O with controller and graphics, and AMBER monitor.

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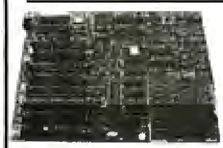
JE1005 (IBM™ PC/XT Turbo Compatible Kit) . $599.95



IBM Compatible Motherboards

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- BIOS ROM included

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JE1001 4.77/8MHz . . ~~$129.95~~ $104.95
JE1000 4.77MHz . . . . ~~$109.95~~ $ 89.95

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Color Graphics Card for PC/XT/AT

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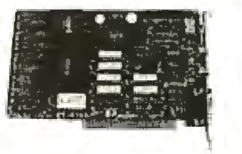
JE1052 . . . . $49.95

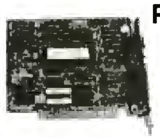
EGA Card for PC/XT/AT



• Graphics: 720 x 348 • 16 out of 64 colors • Manual included

JE1055 . . . . $149.95

I/O Cards for PC/XT/AT

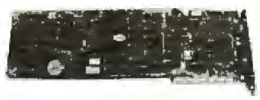


- Printer Port
- RS232 Port
- Game Port
- Manual included

JE1060 (Pictured)

JE1060 I/O for XT $59.95
JE1065 I/O for AT $59.95

Multi I/O w/Controller & Graphics for PC/XT

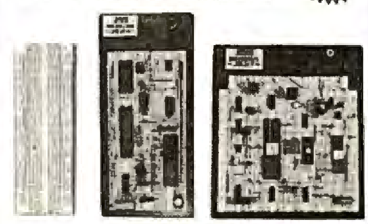


• Printer port • RS232 port • Floppy controller • Graphics • Manual included

JE1071 . . . . $119.95

Jameco ELECTRONICS Solderless Breadboard Sockets

NEW



JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5¾	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

Jameco ELECTRONICS Extended 80-Column Card for Apple *IIe*

• 80 Col./64K RAM • Doubles amount of data your Apple *IIe* can display as well as its memory capacity • Ideal for word processing • Complete with instructions

JE864 $49.95

ADD12 (Disk Drive II, II+, *IIe*) **$99.95**

Additional Apple Compatible Products Available

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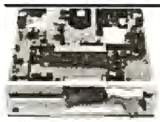
ST225K (Pictured)

ST225 20MB Drive only (PC/XT/AT) $269.95
ST225K 20MB w/Controller (PC/XT) $319.95
ST238K 30MB w/Cont. (PC/XT/AT) . . $339.95
ST251XT 40MB w/Cont. Card (PC/XT) . $549.95
ST251AT 40MB w/Cont. Card (AT) . . . $589.95



Jameco PC/XT & AT Compatible Disk Drives

JE1022 (Pictured)

JE1020 (360K Drive, PC/XT/AT) . . . $ 89.95
JE1022 (1.2MB, AT Compatible) . . . $109.95

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30005	Logic Data Book - Vol. II (84)	$19.95
30009	Intersil Data Book (87)	$14.95
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2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
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TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM8116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19.95
4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.29
4164-120	65536x1	(120ns)	1.55
MCM6665	65536x1	(200ns)	1.95
TMS4164	65536x1	(150ns)	1.95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2.95
TMS4416	16384x4	(150ns)	3.75
41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	2.95
41256-120	262144x1	(120ns)	3.95
41256-100	262144x1	(100ns)	4.95
HM51258-100	262144x1	(100ns)(CMOS)	6.95
1 MB-120	1048576x1	(120ns)	19.95
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2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
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2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.89
2764-200	8192x8	(200ns)(5V)	4.25
MCM68766	8192x8	(350ns)(5V)(24 PIN)	15.95
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27C256	32768x8	(250ns)(5V)(CMOS)	7.95
27256	32768x8	(250ns)(5V)	5.95
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27C512	65536x8	(250ns)(5V)(CMOS)	12.95

5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

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PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

8000

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8085		1.95
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8088		5.99
8088-2		7.95
8155		2.49
8748		7.95
8755		14.95
80286		79.95
80287	6MHz	179.95
80287-8	8MHz	249.95
80287-10	10MHz	309.95

8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	3.95
8237-5	4.75
8250	6.95
8251	1.29
8251A	1.69
8253	1.69
8253-5	1.95
8255	1.49
8255-5	1.59
8259	1.95
8259-5	2.29
8272	4.39
8279	2.49
8279-5	2.95
8282	3.95
8284	2.25
8286	3.95
8288	4.95

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Z80-CPU 2.5 MHz	1.25
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Z80A-SIO/0	5.95
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6500

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6522	2.95
6526	13.95
6532	5.95
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6551	2.95
6561	19.95
6581	14.95
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6520A	2.95
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6532A	11.95
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6551A	6.95
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6502B	4.25

6800

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6800	1.95
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6809	2.95
6809E	2.95
6810	1.95
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6847	4.75
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4.032	1.95
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5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

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4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

MISC.

TMS99531	9.95
TMS99532	19.95
ULN2003	.79
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	19.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.21	74HC148	.79
74HC02	.21	74HC151	.59
74HC04	.25	74HC154	1.09
74HC08	.25	74HC157	.55
74HC10	.25	74HC158	.55
74HC14	.35	74HC163	.65
74HC20	.25	74HC175	.59
74HC27	.25	74HC240	.85
74HC30	.25	74HC244	.85
74HC32	.35	74HC245	.85
74HC51	.25	74HC257	.55
74HC74	.35	74HC259	.55
74HC85	.55	74HC273	.69
74HC86	.45	74HC299	1.29
74HC93	.99	74HC368	.68
74HC107	.39	74HC373	.69
74HC109	.39	74HC374	.69
74HC112	.39	74HC390	.79
74HC125	.55	74HC393	.69
74HC132	.49	74HC4017	.99
74HC133	.39	74HC4020	.89
74HC138	.45	74HC4049	.69
74HC139	.45	74HC4050	.59

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.25	74HCT166	1.39
74HCT02	.25	74HCT174	.59
74HCT04	.27	74HCT193	.85
74HCT08	.25	74HCT194	.85
74HCT10	.25	74HCT240	.89
74HCT11	.27	74HCT241	.79
74HCT27	.29	74HCT244	.89
74HCT30	.25	74HCT245	.99
74HCT32	.27	74HCT257	.79
74HCT74	.45	74HCT259	.89
74HCT75	.45	74HCT273	.99
74HCT138	.55	74HCT367	.79
74HCT139	.55	74HCT373	.99
74HCT154	1.95	74HCT374	.99
74HCT157	.59	74HCT393	.99
74HCT158	.69	74HCT4017	1.19
74HCT161	.79	74HCT4040	.99
74HCT164	.79	74HCT4060	1.49

74F00

74F00	.35	74F74	.39	74F251	.89
74F02	.35	74F86	.55	74F253	.89
74F04	.35	74F138	.79	74F257	.89
74F08	.35	74F139	.79	74F280	1.29
74F10	.35	74F157	.89	74F283	2.95
74F32	.35	74F240	1.29	74F373	1.35
74F64	.55	74F244	1.29	74F374	1.35

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TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges—please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale. A full copy of our terms is available upon request. Items pictured may only be representative.

Circle 138 on Reader Service Card

PRICES SLASHED! DB25 MALE D-SUB 69¢

CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	14497	6.95
4013	.35	4503	.49
4015	.29	4511	.69
4016	.29	4516	.79
4017	.49	4518	.85
4018	.69	4522	.79
4020	.59	4526	.79
4021	.69	4527	1.95
4024	.49	4528	.79
4025	.25	4529	2.95
4027	.39	4532	1.95
4028	.65	4538	.95
4035	.69	4541	1.29
4040	.69	4553	5.79
4041	.75	4585	.75
4042	.59	4702	12.95
4043	.85	74C00	.29
4044	.69	74C14	.59
4045	1.98	74C74	.59
4046	.69	74C83	1.95
4047	.69	74C85	1.49
4049	.29	74C95	.99
4050	.29	74C150	5.75
4051	.69	74C151	2.25
4052	.69	74C161	.99
4053	.69	74C163	.99
4056	2.19	74C164	1.39
4060	.69	74C192	1.49
4066	.29	74C193	1.49
4069	.19	74C221	2.49
4076	.59	74C240	1.89
4077	.29	74C244	1.89
4081	.22	74C374	1.99
4085	.79	74C905	10.95
4086	.89	74C911	8.95
4093	.49	74C917	12.95
4094	2.49	74C922	4.49
14411	9.95	74C923	4.95
14412	6.95	74C926	7.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	2.85
74143	5.95	9602	.69
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.49	74S196	2.49
74S30	.29	74S197	2.95
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

DATA ACQ		INTERFACE	
ADC0800	12.95	8T26	1.29
ADC0804	2.99	8T28	1.29
ADC0809	3.85	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	8.49	8T97	.59
ADC0831	4.49	8T98	.89
DAC0800	3.29	DM8131	2.95
DAC0806	3.29	DP8304	2.29
DAC0808	1.95	DS8833	2.25
DAC1020	6.85	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	1.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-93 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K 5V 3A TO-3 4.79
LM338K Adj. 5A TO-3 6.95

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49

ST=SOLDERTAIL

8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW=WIREWRAP

16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.35
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.69	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	3.49	XR2240	1.95
LM324	.34	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	4.49	CA3130E	.99
LM339	.59	CA3146	1.29
LM340	see 7800	CA3160	1.19
LM350T	4.60	MC3373	1.29
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	1.89
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	.79	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

EDGECARD CONNECTORS

100 PIN	ST	S-100	.125	3.95
100 PIN	WW	S-100	.125	4.95
62 PIN	ST	IBM PC	.100	1.95
50 PIN	ST	APPLE	.100	2.95
44 PIN	ST	STD	.156	1.95
44 PIN	WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36 RIBBON CABLE 3.95
CEN36 SOLDER CUP 1.85

FEMALE

IDCEN36/F RIBBON CABLE 4.95
CEN36PC RT ANGLE PC MOUNT 4.95

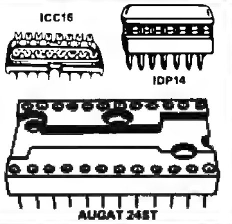
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	1.99
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.49	.59	---	---	---	.85	---	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

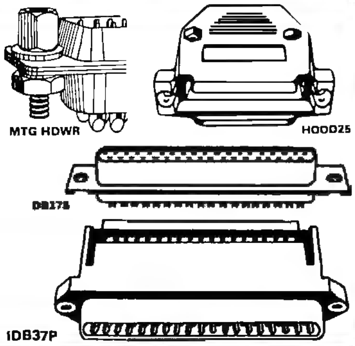
1N751	.15	4N26	.69
1N759	.15	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.69
1N5402	.25	4N37	1.19
KBP02	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	2.25
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	—	.79	2.27	—
	FEMALE	DBxxSR	.55	.75	—	.85	2.49	—
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	—	3.89	5.60	—
	FEMALE	DBxxSWW	2.76	4.27	—	6.84	9.95	—
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	—	2.25	4.25	—
	FEMALE	IDBxxS	1.45	2.05	—	2.35	4.49	—
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	—	—
	GREY	HOODxx	.39	.39	—	.39	.69	.75

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE 59¢



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	9.95

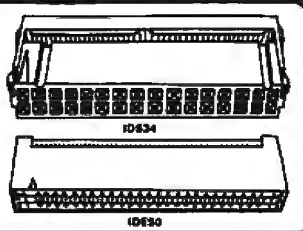
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.60
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O	.39
SPST	MINI-PUSHBUTTON N.C	.39
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.60
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.16
34	.55	5.40	1.07	9.36
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

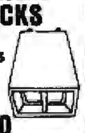
HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS



5/$1.00

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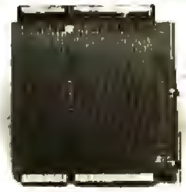

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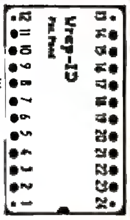

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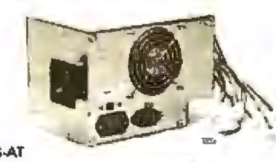

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22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

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.047µf	50V	.15	.47µf	50V	.25

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4.7	50V	.11	22	16V	.14
10	50V	.11	47	50V	.19
47	35V	.13	100	35V	.19
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WBU-208

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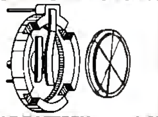

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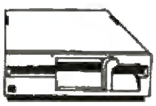

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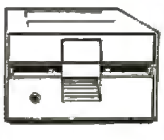

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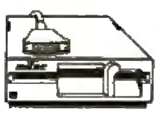

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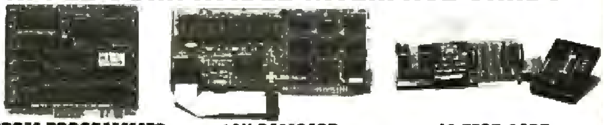

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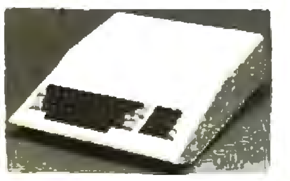

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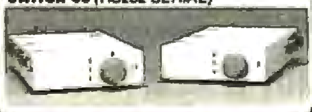

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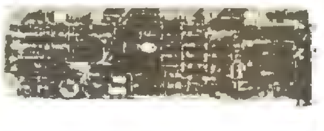

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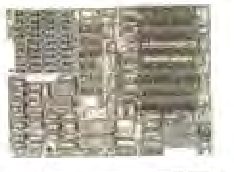

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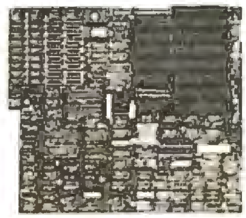

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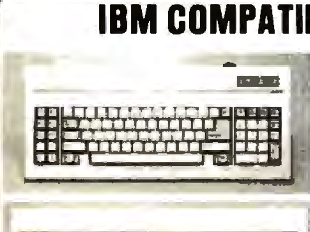

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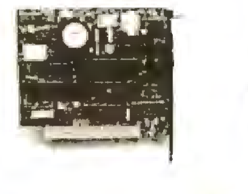

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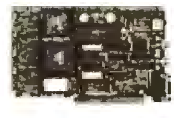

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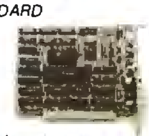

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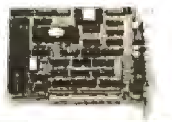
COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS



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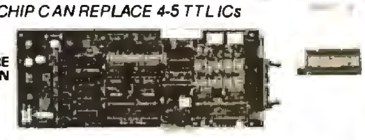

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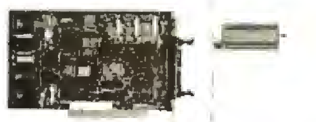

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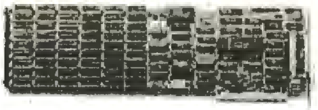

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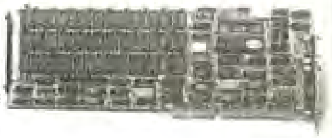

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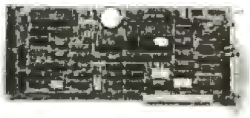

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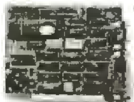

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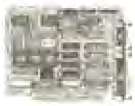

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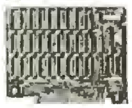

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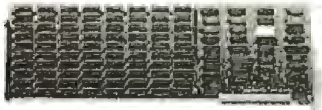

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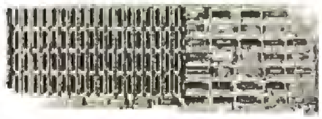

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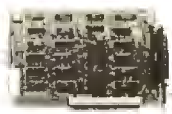

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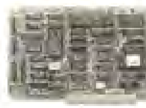

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YOU CHOOSE THE BEST ARTICLE EACH MONTH

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.

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BOMB RESULTS

The results for July find What's New from the BYTE staff walking off with top honors. Richard Grehan takes second for his review, "The IBM PS/2 Model 50." Microbytes, also from the BYTE staff, shows in third. The fourth-place finisher is Curtis Franklin Jr. for his review, "The IBM PS/2 Model 30." In fifth place, and this month's winner of $100, is Dick Lefkon for "A LAN Primer." Steve Ciarcia's "Using the ImageWise Video Digitizer, Part 1: Image Processing" is sixth. "A Taxing Day" gains seventh place for Jerry Pournelle. "High-Tech Horsepower," another BYTE staff effort, lands in eighth place. David Gedeon wins $50 for a Programming Insight, "Complex Math in Pascal." The $50 award for quality goes to Mr. Lefkon.

We also have the results for our *Applications Software Today* special issue. In first place, and the winner of $100, is Phillip Robinson for his review, "Word Processors." The second-place finisher, and winner of $50, is Bill Gates for "Beyond Macro Processing." Mr. Robinson also wins the $50 award for quality. Congratulations to all.

COMING UP IN BYTE

Products In Perspective:

BYTE will have a new look beginning in November, and the Products in Perspective section is an example. One new type of article, called First Impressions, will provide the very latest information about new products while retaining the depth of coverage traditional to BYTE.

Reviews:

There's a new perspective in the review section, too. We'll lead off with a group review—80286 accelerator boards, in November—and follow it with a BIX-generated discussion on the product category in question.

System reviews include the IBM PS/2 Model 80 and two other 80386-based machines. Peripherals include upgrades for the Mac SE and pocket modems. Languages include a group review of FORTRANs and MetaWare C/386. Applications include Finite Element Analysis and Wordcruncher.

In Depth:

This new name for the Theme section gives a clearer indication of its role—to focus on a particular segment of microcomputing and discuss it in depth. Workstations are covered in November, and we'll have a roundup article, a windowing system comparison, Apple Unix on the Macintosh, standards, and graphics engines.

Features:

Steve Ciarcia begins a two-part article on building an integrated circuit tester. Other features are an algorithm for XMODEM CRCs and Dick Pountain's article on algorithms for a freehand paint program.

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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1. □ □ □ [#] [#]   6. □ □ □ [#] [#]   10. □ □ □ [#] [#]   14. □ □ □ [#] [#]
2. □ □ □ [#] [#]   7. □ □ □ [#] [#]   11. □ □ □ [#] [#]   15. □ □ □ [#] [#]
3. □ □ □ [#] [#]   8. □ □ □ [#] [#]   12. □ □ □ [#] [#]   16. □ □ □ [#] [#]
4. □ □ □ [#] [#]   9. □ □ □ [#] [#]   13. □ □ □ [#] [#]   17. □ □ □ [#] [#]
5. □ □ □ [#] [#]

END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

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Index to Advertisers by Product Category

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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
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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
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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

* To determine this month's Article No., see BOMB as listed in Table of Contents under Departments.

Name ______
Title ______
Company ______
Address ______
City ______
State ______ Zip ______
Telephone ______

A. What is your principal occupation? (Please check one only.)
1. ☐ Business Owner
2. ☐ Manager/Administrator
3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify) ______

B. How many people does your company employ?
1. ☐ 1–49
2. ☐ 50–999
3. ☐ 1,000 or more

C. Information requested for:
1. ☐ Business use
2. ☐ Personal use
3. ☐ Both

D. Do you plan to purchase items inquired about within:
1. ☐ Next 3 months?
2. ☐ Next 6 months?
3. ☐ Next 12 months?

E. Please check the statement that best describes your involvement in your company's purchasing decisions. (Check all that apply.)
1. ☐ I determine the need
2. ☐ I evaluate products/systems
3. ☐ I select/recommend the vendor
4. ☐ I approve/authorize the purchase

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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

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Title ______
Company ______
Address ______
City ______
State ______ Zip ______
Telephone ______

A. What is your principal occupation? (Please check one only.)
1. ☐ Business Owner
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3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify) ______

B. How many people does your company employ?
1. ☐ 1–49
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C. Information requested for:
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